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TRANSACTIONS

OF THE

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OF

ELECTRICAL ENGINEERS.

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

CATALOGUE OF MEMBERS.

FEBRUARY 1ST, 1895.

HONORARY MEMBERS.

Name.	Address.	Date of Membership.
KELVIN, *Lord*,	*LL.D.*, *F.R.S.S.L.* and *E.* The University, Glasgow, Scotland,	H.M. May 17, 1892
PREECE, WM. H. *F.R.S.*	Electrician, General Post Office, London, Eng. Residence, Gothic Lodge, Wimbledon.	H.M. Oct. 21, 1884

Total, 2.

MEMBERS.

ABBOTT, ARTHUR V.	Chief Engineer, Chicago Telephone Co., 203 Washington St., Chicago, Ill.	A Oct. 21, 1890 M Jan. 16, 1895
ACHESON, EDW. G.	Electrician and Electrical Engineer, Carborundum Co., Monongahela City, Pa.	A Jan. 3, 1888 M May 1, 1888
ADAMS, ALTON D.	Electrical Engineer, 620 Atlantic Ave., Boston, Mass.	A April 18, 1893 M Jan. 17, 1894
AHEARN, T.	Ahearn & Soper, Electrical Supplies, Ottawa, Ont.	A July 12, 1887 M Sept. 6, 1887
ALBRIGHT, H. FLEETWOOD	Electrical Engineer, Western Electric Co., New York; residence, 5304 Lancaster Ave., Philadelphia, Pa.	A Sept. 27, 1892 M June 20, 1894
ALMON, G. H.	Electrical Engineer and Contractor, 136 Liberty St., New York City, and 620 Atlantic Ave., Boston, Mass.	A Sept. 20, 1893 M Mar. 21, 1894
ANTHONY, PROF. W. A.	(*Past President.*) (*Vice-President.*) Consulting Electrician, Temple Court, New York, N. Y.	A Dec. 9, 1884 M Jan. 6, 1885
ARNOLD, BION J.	Consulting Electrical Engineer, 574 The Rookery and 4128 Prairie Ave., Chicago, Ill.	A Oct. 25, 1892 M Nov. 15, 1893

Name.	Address.	Date of Membership.
AYER, JAMES I.	James I. Ayer & Co., Consulting Engineers, Security Building St. Louis Mo.; Manager, Marks-Ayer Electric Co., 73 Watt St., New York City; residence, Plainfield, N. J.	A May 19, 1891 M April 19, 1892
AYRES, BROWN	Professor of Physics and Electrical Engineering, Tulane University, New Orleans, La.	A Dec. 16, 1891 M Mar. 25, 1892
BAILLARD, E. V.	Manufacturer of Electrical Instruments and Fine Machinery, 106 Liberty St., New York City.	A Dec. 3, 1889 M Jan. 16, 1895
BARBERIE, E. T.	Electrician, 159 W. 66th St., New York City.	A Jan. 19, 1892 M Oct. 25, 1892
BATCHELOR, CHAS.	Electrical Engineer, 33 West 25th St., New York City.	A June 8, 1887 M July 12, 1887
BATES. J H.	Assistant Engineer and Draughtsman, with C. J. Bates & Co., 126 Liberty St., New York City, and 321 Hudson St., Hoboken, N. J.	A Sept. 6, 1887 M Oct. 1, 1889
BATES, MAURICE E.	Electrician National Electric Mfg. Co., Eau Claire, Wis.	A Aug. 6, 1880 M Oct. 1, 1889
BAYLIS, ROBERT N.	Electrical Engineer, 81 Fulton St., New York City.	A Oct. 1, 1889 M May 17, 1892
BELL, PROF. A. GRAHAM	(*Past President.*) 1331 Conn. Ave., Washington, D. C., and Baddeck, N. S.	A April 15, 1884 M Oct. 21, 1884
BELL, DR. LOUIS	Electrical Engineer, General Electric Co., Monadnock Bldg., Chicago, Ill.	A May 20, 1890 M June 18, 1890
BENJAMIN, PARK	Electrical Expert and Engineer, 203 Broadway, N. Y. City.	A Dec. 16, 1891 M Feb. 16, 1892
BERNARD, EDGAR G.	Electrical Engineer, President, E. G. Bernard & Co., 43 4th St., Troy, N. Y.	A. Jan. 5, 1886 M July 12, 1887
BINNEY, HAROLD	Patent Solicitor and Expert, Potter Building, 38 Park Row, New York City.	A Sept. 16, 1890 M Dec. 16, 1890
BIRDSALL, E. T. *M. E.*	Consulting Electrical Engineer, 18 Broadway; Residence, 56 West 38th St., New York.	A June 8, 1887 M Nov. 1, 1887
BISHOP, JAMES DRAPER	Electrical Engineer of the Safety Insulated Wire and Cable Co., 234 W. 29th St., New York City.	A Dec. 16, 1891 M Oct. 25, 1892
BLAKE, FRANCIS	Auburndale, Mass.	A Sept. 3, 1889 M Oct. 1, 1889
BLODGETT, GEO. W.	Electrical Engineer. B. & A. R. R. and Consulting Electrician, Boston, Mass.	A July 12, 1887 M Sept. 6, 1887
BOSCH, ADAM	Sup't Fire Alarm Telegraph, Newark, N. J.	A April 15, 1884 M Jan. 6, 1885
BOSSON, FREDERICK N.	Consulting Mining and Electrical Engineer; Electrician, Calumet and Hecla Mining Co., Calumet, Mich.	A May 17, 1892 M Feb. 21, 1893

Name.	Address.	Date of Membership.
BOURNE, FRANK	Electrical Engineer, 1322 Havemeyer Building, New York City.	A April 21, 1891 M Nov. 15, 1892
BOWMAN, FRED. A.	Supt., New Glasgow Electric Co., New Glasgow, Nova Scotia.	A May 19, 1891 M Nov. 21, 1894
BOYNTON, EDWARD C.	Electrician of the Lovell Mfg. Co., Ltd., 156 W. 8th St., Erie, Pa.	A Aug. 6, 1889 M Nov. 24, 1891
BRADLEY, CHAS. S.	(*Manager.*) Electrical Engineer, 1919 Seventh Ave., New York City.	A May 24, 1887 M Dec. 6, 1887
BRENNER, WILLIAM H.	Electrical Engineer, 39 Cortlandt St., New York City.	A Sept 20, 1893 M Mar. 21, 1894
BROADNAX, FRANCIS	Engineer, Safety Insulated Wire and Cable Co., 50 Broadway, New York City; residence, 47 Christopher St., Montclair, N. J.	A Jan. 17, 1894 M Jan. 16, 1895
BROOKS, MORGAN	President and Manager, The Electrical Engineering Co., 249 Second Ave., South; residence, 2950 Park Ave., Minneapolis, Minn.	A May 20, 1890 M June 17, 1890
BROWN, ALFRED S.	Electrical Engineer, Western Union Telegraph Co., 195 Broadway, P. O. Box 856, New York City.	A Mar. 18, 1890 M Feb. 21, 1893
BROWN, J. STANFORD, *E. E.*,	Consulting and Constructing Electrical Engineer, 126 Liberty St., New York City; residence, Park Hill, Yonkers, N. Y.	A Sept. 6, 1887 M Nov. 1, 1887
BRUSH, CHAS. F.	Electrical Engineer, 453 The Arcade, Cleveland, O.	A April 15, 1884 M Oct. 21, 1884
BURLEIGH, CHAS. B.	Supt. Isolated Dept. General Electric Co., 620 Atlantic Ave., Boston, Mass.	A April 21, 1891 M Feb. 16, 1892
BYLLESBY, HENRY M.	Northwest General Electric Co., 403 Sibley St., St. Paul, Minn.	A Sept. 7, 1888 M Oct. 2, 1888
CAHOON, JAS. B.	Electrical Engineer, Manager, Expert Dept., General Electric Co., 226 Union St., Schenectady, N. Y.	A June 17, 1890 M May 19, 1891
CARROLL, LEIGH	[Address unknown.]	A Oct. 1, 1889 M Nov. 12, 1889
CHAMBERLAIN, J. C.	Electrical Engineer, 135 East 18th St., New York City.	A Dec. 6, 1887 M Jan. 3, 1888
CHANDLER, PROFESSOR CHARLES F.	Columbia College, 41 East 49th St., New York City.	A Jan. 20, 1891 M June 7, 1892
CHENEY, W. C.	Superintendent and Electrical Engineer, General Electric Co., Portland, Ore.	A Sept. 22, 1891 M Nov. 21, 1894
CHURCHILL, ARTHUR	Engineering Dept., Schenectady Works, General Elec. Co., 5 So. Church St., Schenectady, N. Y.	A April 15, 1890 M Jan. 17, 1893
CLARK, ERNEST P.	Electrical Engineer, Clark Electric Co, 192 Broadway, New York City.	A Jan. 8, 1887 M Nov. 1, 1887
CLARKE, CHAS. L.	Electrical Engineer and Patent Expert, 55 Liberty St., New York City.	A April 15, 1884 M Jan. 6, 1885

Name.	Address.	Date of Membership.
COLBY, EDWARD A.	Consulting Engineer, Lock Box 313, Newark, N. J.	A April 2, 1889 M May 7, 1889
CONDICT, G. HERBERT	Electrical Engineer, 5328 Green St., Germantown, Pa	A July 12, 1887 M Sept. 6, 1887
COTHREN, WM. H.	The Cincinnati Edison Electric Co., 164 W. 8th St., Cincinnati, O.	A Aug. 6, 1889 M Oct. 1, 1889
COWLES, ALFRED H.	Technical Adviser to the Cowles Smelting and Aluminum Co., 656 Prospect St., Cleveland, O.	A Mar. 5, 1886 M May 7, 1889
CRAIGIN, HENRY A.	Engineer, Westinghouse Electric and Mfg. Co., 120 Broadway, New York City.	A June 6, 1893 M May 15, 1894
CRANDALL, JOSEPH EDWIN	Electrician, C. & P. Telephone Co., 619 Fourteenth St., N. W. Washington, D. C.	A April 18, 1892 M April 18, 1894
CROCKER, FRANCIS B. [Life Member.]	(*Vice-President*) Professor of Electrical Engineering, School of Mines, Columbia College, New York.	A May 24, 1887 M April 2, 1889
CROSS, PROF. CHAS. R.	Thayer Professor of Physics, and Director of the Rogers Laboratory, Mass. Institute of Technology, Boston, Mass.	A April 15, 1884 M Oct. 21, 1884
CURTISS, GEORGE F.	Electrical Engineer, General Electric Co., Schenectady, N. Y.	A April 2, 1889 M Nov. 24, 1891
CUTTER, GEORGE	Dealer in Electrical Supplies, 851 The Rookery, Chicago, Ills.	A June 17, 1890 M May 19, 1891
CUTTRISS, CHAS.	Electrician, The Commercial Cable Co., 1 Broad St., New York.	A Nov. 1, 1887 M Dec. 6, 1887
DAFT, LEO	Consulting Electrical Engineer and Contractor, Burke Building, Seattle, Wash.	A Dec. 9, 1884 M Jan. 6, 1885
DANIELL, FRANCIS G.	Electrical Engineer, Fairhaven and Westville R. R. Co., P. O. Box 394, New Haven, Conn.	A Nov. 12, 1889 M June 20, 1894
DANVERS, ALAN	[Address unknown.]	A Nov. 1, 1887 M Sept. 3, 1889
DAVIES, JOHN E.	Professor of Physics, University of Wisconsin, 523 North Carroll St., Madison, Wis.	A Jan. 7, 1890 M Mar. 18, 1890
DAVIS, CHARLES H., *C. E.*,	Consulting and Constructing Engineer, 120 Broadway, New York City, and 308 Walnut St., Philadelphia, Pa.	A Mar. 18, 1890 M June 17, 1890
DAVIS, MINOR M.	Ass't Electrician, Postal Telegraph Cable Co., 253 Broadway, New York City	A April 6, 1886 M May 16, 1893
DELAFIELD, A. FLOYD, *Ph. D.*	Electrical Engineer, Noroton, Conn.	A May 7, 1889 M Oct. 1, 1889
DELANY, PATRICK BERNARD	(*Vice President.*) Inventor, South Orange, N. J.	A April 19, 1884 M Nov. 24, 1891
DICKENSON, SAMUEL S.	Sup't, Commercial Cable Co., Hazel-Hill, Guysborough Co., N. S.	A Mar. 6, 1888 M Oct. 1, 1889

Name.	Address.	Date of Membership.
DIEHL, PHILIP	Inventor, Singer Sewing Machine Co., 508 Morris Ave., Elizabeth, N. J.	A April 15, 1884 M Dec. 9, 1884
D'INFREVILLE, GEORGES	Electrical Engineer and Expert, 10 Desbrosses St., New York City.	A Nov. 1, 1887 M Dec. 6, 1887
DION, ALFRED A.	General Supt., The Ottawa Electric Co , 72 Sparks St., Ottawa, Ont.	A Jan. 7, 1890 M Nov. 15, 1893
DOIJER. H.	Consulting Electrical Engineer, 8 Choorstraat, Delft, Holland.	A Jan. 7, 1890 M Mar. 18, 1890
DONNER, WILLIAM H.	241 Sixth Ave., Newark, N. J.	A Nov. 18, 1890 M Dec. 16, 1890
DUDLEY, CHARLES B.	Chemist and Scientific Expert, Penn. R. R. Co., 1219 Twelfth Ave., Altoona, Pa.	A Oct. 1, 1889 M Nov. 12, 1889
DUNBAR, F. W.	425 West 22nd St., New York City.	A Dec. 21, 1892 M May 16, 1893
DUNCAN, DR. LOUIS	Johns Hopkins University, Baltimore, Md. Firm of Sprague, Duncan & Hutchinson, 253 Broadway, New York City.	A July 12, 1887 M Sept. 6, 1887
DUNN, GANO S.	Electrical Engineer, of the Crocker-Wheeler Electric Co., Ampere, E. Orange, N J.; Residence, 223 Central Park, West, New York City.	A April 21, 1891 M June 20, 1894
DUNSTON, ROBT. EDWARD	The Cortland and Homer Traction Co., Cortland, N. Y.	A Oct 27, 1891 M Feb. 16, 1892
DYER, R. N.	Patent Attorney, 36 Wall St., New York City.	A July 12, 1887 M Sept. 6, 1887
EDISON, THOMAS A.	Mechanician and Inventor, Orange, N. J.	A April 15, 1884 M Oct. 21, 1884
EGGER, ERNST	Electrical Engineer care of B. Egger & Co , X., Sinmeringstr, 187, Vienna, Austria.	A Feb 21, 1893 M Mar. 21, 1894
EMERY, CHARLES EDWARD	Consulting Engineer, 915 Bennett Building, cor. Fulton and Nassau Sts., New York City.	A June 26, 1891 M April 19, 1892
EMMET, W. L. R.	Electrical Engineer, General Electric Co., Schenectady, N. Y.	A June 6, 1893 M Jan. 17, 1894
EUSTIS, HERBERT H.	President and Electrician, Eastern Electric Cable Co., 61 Hampshire St., Boston, Mass.	A April 15, 1890 M Nov. 24, 1891
EVEREST, AUGUSTINE R.	Electrical Engineer, Thomson Electric Welding Co., Lynn, Mass.	A May 19, 1891 M Dec. 20, 1893
FARNHAM, ISAIAH H.	Electrical Engineer, N. E. Telephone & Telegraph Co., 125 Milk St., Boston, Mass.	A June 8, 1887 M July 12, 1887
FESSENDEN, REGINALD A.	Professor of Electrical Engineering, Western University of Pennsylvania, Allegheny, Pa.	A Oct. 21, 1890 M Dec. 16, 1890

Name.	Address.	Date of Membership.
FIELD, C. J., *M. E.*	Consulting and Constructing Engineer, Havemeyer Building, 26 Cortlandt St., New York City.	A June 8, 1887 M Nov. 1, 1887
FIELD, STEPHEN D.	Electrical Engineer, Stockbridge, Mass.	A April 15, 1884 M Oct. 21, 1884
FITZMAURICE, JAMES S.	Chief Engineer, The Electric Light Branch, 210 George St., Sydney, N. S. W.	A Sept. 20, 1893 M Mar. 21, 1894
FLEMING, WILFRID H.	70 W. 3d St., Bayonne City, N. J.	A Dec. 6, 1887 M Jan. 3, 1888
FOSTER, HORATIO A.	Electrical Engineer, Chief Assistant, Prof. George Forbes, Rooms 25 and 26, 4th Floor, 35 Wall St., Editor, *Electric Power;* residence, 569 Park Ave., New York City.	A June 8, 1887 M Sept. 6, 1887
FREEMAN, DR. FRANK L.	Attorney-at-Law, Solicitor of Patents, Electrical Expert, 931 F St., Washington, D. C.	A May 7, 1889 M Sept. 3, 1889
GALE, HORACE B.	Consulting Electrical and Mechanical Engineer, 40 California St., San Francisco, Cal.	A Nov. 15, 1892 M May 16, 1893
GEYER, DR. WM. E.	Stevens Institute of Technology, Hoboken, N. J.	A June 5, 1888 M Sept. 7, 1888
GIFFORD, CLARENCE E.	Electrical Engineer, Supt. Jamestown Electric Light and Power Co., Jamestown, N. Y.	A May 16, 1893 M Feb. 21, 1894
GRAY, DR. ELISHA	Electrician and Inventor, Highland Park, Ill.	A Feb. 16, 1892 M May 17, 1892
GREENE, S. DANA	Assistant General Manager, General Electric Co., Schenectady, N. Y.	A Sept. 20, 1893 M April 18, 1894
GRISCOM, WM. W., *M.A.*	Electrical Engineer, 224 Chestnut St., Philadelphia; residence, Haverford, Pa.	A June 5, 1888 M Mar. 18, 1890
GUTMANN, LUDWIG	Electrical Engineer, care of *Street Railway Review*, 269 Dearborn St., Chicago, Ill.	A Sept. 14, 1888 M Mar. 21, 1893
HALL, CLAYTON C.	Civil Engineer, 810 Park Ave., Baltimore, Md.	A April 15, 1884 M Oct. 21, 1884
HALL, JOHN L.	Manager, Western Union Telegraph Co., 300 Market St., Wilmington, Del.	A Sept. 22, 1891 M Dec. 20, 1893
HAMBLET, JAMES	(*Vice-President.*) Manager Time Service, W. U. Tel. Co., 195 Broadway, P. O. Box 856, New York City; residence, 20 Sidney Place, Brooklyn, N. Y.	A Nov. 1, 1887 M Dec. 6, 1887
HAMILTON, GEO. A.	Electrician, Western Electric Co., 22 Thames, cor. Greenwich St., New York; residence, 532 Morris Ave., Elizabeth, N. J.	A April 15, 1884 M Oct. 21, 1884

Name.	Address.	Date of Membership.
HAMMER, WILLIAM J.	(*Manager.*) Consulting and Supervising Electrical Engineer, 1305 Havemeyer Building, 26 Cortlandt St., New York City; residence, Elmora, N. J.	A June 8, 1887 M July 12, 1887
HASKINS, CARYL D.	Electrical Engineer, General Electric Co., 620 Atlantic Ave., Boston, Mass.	A Mar. 18, 1890 M June 20, 1894
HASKINS, CHARLES H.	Electrician, care of Judge T. C. White, Superior Court Chambers, Buffalo, N. Y.	A April 15, 1884 M Oct. 21, 1884
HASKINS, CLARK CARYL	City Electric Light Inspector, 582 West Congress St., Chicago, Ill.	A Sept. 20, 1893 M Mar. 21, 1894
HASSON, W. F. C.	Firm of Hasson & Hunt, Consulting and Supervising Mechanical and Electrical Engineers, 310 Pine St., Telephone 5650, San Francisco, Cal.	A Mar. 18, 1890 M May 15, 1894
HAYES, HAMMOND V.	Electrician, American Bell Telephone Co., 42 Farnsworth St., So. Boston Mass.	A Nov. 12, 1889 M Mar. 18, 1890
HAYES, HARRY E.	Asst. Electrician, American Telegraph and Telephone Co., 153 Cedar St., New York City.	A April 18, 1893 M Dec. 20, 1893
HAYNES, F. T. J.	Divisional Telegraph Engineer, Great Western Railway, Residence, Belmont Villa, Cheddon Road, Taunton, Eng.	A Dec. 6, 1886 M Jan. 3, 1887
HEINRICH, RICHARD O.	Electrical Engineer, Weston Electrical Instrument Co., 114 William St., Newark, N. J.	A Oct. 1, 1889 M Oct. 25, 1892
HERING, CARL	Consulting Electrical Engineer, 927 Chestnut St., Philadelphia, Pa.	A Jan. 3, 1888 M June 5, 1888
HERING, HERMANN S.	Associate in Electrical Engineering, Johns Hopkins University, Baltimore, Md.	A April 21, 1891 M April 18, 1893
HERRICK, CHARLES H.	Manager and Electrical Engineer, Wright Electrical Engineering Co., 196 Summer St., Boston; residence, 132 Highland Ave., Winchester, Mass.	A April 21, 1891 M Jan. 17, 1893
HERZOG, DR, F. BENEDICT	President, Herzog Teleseme Co., 30 Broad St., New York City.	A May 24, 1887 M July 12, 1887
HEWITT, CHARLES	(*Manager.*) Assistant Engineer, Philadelphia Traction Co., 920 Spruce St., Philadelphia, Pa.	A Sept. 16, 1890 M May 17, 1892
HIBBARD, ANGUS S.	(*Manager.*) General Manager, Chicago Telephone Co., 203 Washington St., Chicago, Ill.	A Nov. 24, 1891 M Feb. 16, 1892
HIGGINS, EDWARD E.	Expert in Street Railway Values and Economics, 26 Cortlandt St., New York City.	A June 8, 1887 M July 12, 1887

Name.	Address.	Date of Membership.
HOLMES, FRANKLIN S.	Electrical Engineer, 108 Fulton St., New York City; residence 445a Macon St., Brooklyn, N. Y.	A April 21, 1891 M June 20, 1894
HOUSTON, EDWIN J., *Ph.D.* [Life Member.]	(*President.*) Prof. of Physics, Franklin Inst., Firm of Houston & Kennelly, 1105 Betz Bldg.; residence 1809 Spring Garden St., Philadelphia, Pa.	A April 15, 1884 M Oct. 21, 1884
HOWELL, JOHN W.	Electrician, 761 High St., Newark, N. J.	A July 12, 1887 M June 5, 1888
HOWELL, WILSON S.	General Electric Lamp Works, Harrison, N. J.; residence, 19 Webster Place, Orange, N. J.	A Sept. 3, 1889 M Mar. 18, 1890
HUNTER, RUDOLPH M.	Expert and Counsellor in Patent Causes, 926 Walnut St., Philadelphia, Pa.	A July 13, 1886 M May 17, 1887
HUNTING, FRED S.	Chief Engineer, Fort Wayne Electric Co., 330 West Washington St., Fort Wayne, Ind.	A Nov. 15, 1892 M May 16, 1893
HUTCHINSON, DR. CARY T.	Electrical Engineer, Firm of Sprague, Duncan & Hutchinson, 253 Broadway; residence, 56 West 25th St., New York City.	A Feb. 7, 1890 M Dec. 16, 1890
HYDE, JEROME W.	Springfield, Mass.	A June 8, 1887 M Nov. 1, 1887
INRIG, ALEC GAVAN	Rue St. Gommaire, 23, Antwerp, Belgium.	A Jan. 19, 1892 M May 17, 1892
IVES, EDWARD B.	Chief Engineer, Electric Traction Co. of Philadelphia, 421 Chestnut St., Philadelphia, Pa.	A April 2, 1889 M May 15, 1894
JACKSON, DUGALD C.	Professor of Electrical Engineering, University of Wisconsin, Madison, Wis.	A May 3, 1887 M June 17, 1890
JACKSON, FRANCIS E.	Aylsworth & Jackson, Incandescent Filament Manufacturers, 128 Essex Ave, Orange; residence, 61 South Grove St., East Orange, N. J.	A Jan. 3, 1888 M June 17, 1890
JACKSON, HENRY	Telegraph Supt. and Engineer, The Lancashire & Yorkshire Railway Co., Horwich, Bolton-le-Moors, Lancashire, England.	A Mar. 21, 1894 M Dec. 19, 1894
JACKSON, J. P.	Professor of Electrical Engineering, Penn. State College, State College, Pa.	A Sept. 27, 1892 M Jan. 17, 1894
JANNUS, FRANKLAND	Attorney-at-Law, Solicitor of Patents, 928-30 F. St., N. W. Washington, D. C.	A Nov. 12, 1889 M Mar. 18, 1890
JENKS, W. J.	Patent Department. General Electric Co., 44 Broad Street, Box 3067, New York City.	A June 8, 1887 M Nov. 1, 1887
JOHNSTON, A. LANGSTAFF	Consulting Engineer, Hestonville, Mantua and Fairmount Passenger R.R Co, 4300 Lancaster Ave., Philadelphia, Pa.	A April 21, 1891 M April 18, 1894

Name.	Address.	Date of Membership.
JONES, FRANCIS W. [Life Member.]	Assistant Gen'l-Manager and Electrician, Postal Telegraph-Cable Co., 253 Broadway, New York City.	A April 15, 1884 M Oct. 21, 1884
KEITH, DR. NATHANIEL S.	Sandycroft Foundry, E. W. Co., Hawarden, near Chester, Eng.	A June 6, 1893 M Jan. 17, 1894
KINSMAN, FRANK E.	Electrical Engineer and President Kinsman Block Signal Co., 143 Liberty St., New York City and Plainfield, N. J.	A Sept 27, 1892 M May 16, 1893
KNOWLES, E. R.	Electrical Engineer, The Schuyler Electric Company, Middletown, Conn.	A June 8, 1887 M July 12, 1887
KNUDSON, A. A.	Electrical Engineer, 106 Fulton St., New York City.	A Dec. 6, 1887 M Jan. 3, 1888
LANGE, PHILIP A.	Superintendent Westinghouse Electric and Manufacturing Co., East Pittsburg, Pa.	A Mar. 6, 1888 M June 5, 1888
LANGTON, JOHN	Electrical Engineer, Canada Life Building, Toronto, Ont.	A Mar. 6, 1888 M June 5, 1888
LATTIG, J. W.	Electrical Engineer, Supt. of Telegraph and Electrical Apparatus, Lehigh Valley R. R. Co., So. Bethlehem, Pa.; residence, 335 Broad St., West Bethlehem, Pa	A June 8, 1887 M July 12, 1887
LAWSON, A. J.	Electrical Engineer and Contractor, Grantown, Scotland.	A Mar. 18, 1890 M June 17, 1890
LEMP, HERMANN, JR.	Electrician, Thomson Electric Welding Co., Lynn, Mass.	A April 2, 1889 M Feb. 21, 1893
LEONARD, H. WARD	(*Vice President.*) 44 Broad St.; residence, 38 West 35th St., New York City.	A July 12, 1887 M Sept. 6, 1887
LEONARD, M. B.	Electrical Engineer, and Supt. of Telegraph, Chesapeake & Ohio R'y. Co., Richmond, Va.	A Nov. 6, 1886 M May 1, 1888
LIEB, JOHN W., JR.	Electrical Engineer, Edison Electric Ill. Co.; Residence, 166 West 97th St., New York City.	A Sept. 6, 1887 M Nov. 1, 1887
LLOYD, ROBERT McA.	Electrician, 27 Pine St.; residence, 1 West 39th St, New York City.	A Oct. 21, 1890 M Nov. 15, 1893
LOCKWOOD, THOMAS D., [Life Member.]	*F. I. Inst.* Electrical Engineer, and Advisory Electrician, P.O. Drawer 2, Boston, Mass.	A April 15, 1884 M Oct. 21, 1884
LORRAIN, JAMES GRIEVE	Norfolk House, Norfolk St., London, W. C., England.	A May 16, 1891 M May 15, 1894
LOVEJOY, J. R.	General Manager, Supply Dept., General Electric Co., Schenectady, N. Y.	A April 21, 1891 M Feb. 21, 1894
MACFARLANE, ALEXANDER,	*D. Sc., LL.D.* 84 Heustis St., Ithaca, N. Y	A Jan. 19, 1892 M May 17, 1892
MAILLOUX, C. O.	Consulting Electrical Engineer, 45 William St., New York City.	A April 15, 1884 M Oct. 21, 1884

Name.	Address.	Date of Membership.
MANSFIELD, ARTHUR NEWHALL	Assistant Electrician, American Telephone and Telegraph Co., 153 Cedar St., New York City.	A Dec. 20, 1893 M June 20, 1894
MARKS, LOUIS B., *M. M. E.*	Engineer-in-Chief, Marks-Ayer Electric Co., 73 Watt St.; residence, 51 East 67th St., New York City.	A May 20, 1890 M Jan. 16, 1895
MARKS, WILLIAM DENNIS, *Ph.B. C. E.*	Edison Electric Light Co., Philadelphia, Pa.	A Feb. 7, 1888 M May 1. 1888
MARSHALL, J. T.	Metuchen, N. J.	A Oct. 1, 1889 M Nov. 12, 1889
MARVIN, HARRY N.	Secretary and Expert, Marvin Electric Drill Co., 208 South Geddes St., Syracuse, N. Y.	A April 19, 1892 M Jan. 17, 1893
MAYER, WILLIAM, JR.	Electrical Expert and Consulting Electrical Engineer, 31 Nassau St., New York City.	A July 12, 1887 M April 21, 1891
MAYER, GEORGE M.	Room 5, 71 Randolph St., Chicago, Ill.	A Dec. 16, 1890 M June 20, 1894
MAYNARD, GEO. C.	Electrical Engineer, 800 H. St., N. W., Washington, D. C.	A April 15, 1884 M Dec. 9, 1888
MCCAY, H. KENT	Electrical Engineer and Contractor, 106 E. German St., Baltimore, Md.	A Sept. 16, 1890 M May 19, 1891
MCCLUER, C. E.	Superintendent, First District, So. Bell Telephone and Telegraph Co., P. O. Box 32. Richmond, Va.	A Mar. 21, 1893 M Jan. 17, 1894
METCALFE, GEORGE R.	Electrical Engineer, 404 West 22d St., New York City.	A April 19, 1892 M Nov. 15, 1892
MILLIS, JOHN	Captain of Engineers U. S. A., The Lighthouse Board, Washington, D. C.	A July 7, 1884 M Mar. 3, 1885
MILLS, FRANK P.	Superintendent Cleveland Iron Mining Co., Ishpeming, Mich.	A Jan. 6, 1885 M Mar. 3, 1885
MOLERA, E. J.	Civil Engineer, 606 Clay St., San Francisco, Cal.	A Jan. 16, 1892 M June 7, 1892
MOORE, D. MCFARLAN	Inventor, Moore Electrical Co., 321 Harrison St., Harrison, N. J.	A Dec. 20, 1893 M June 20, 1894
MORROW, JOHN THOMAS	Supt. Electrolytic Plant, Boston and Montana Consolidated Copper and Silver Mining Co., Great Falls, Mont.	A Dec. 21, 1892 M April 18, 1894
NICHOLS, DR. EDWARD L.	Professor of Physics, Cornell University, Ithaca, N. Y.	A Oct. 4, 1887 M Dec. 6, 1887
NOLL, AUGUSTUS	Firm of Noll & MacLean, Contracting Electrical Engineers, 8 East 17th St., New York City.	A Sept. 27, 1892 M April 18, 1893
PAINE, F. B. H.	Westinghouse Electric and Mfg. Co., 620 Atlantic Ave., Boston, Mass.	A Dec. 16, 1890 M Nov. 25, 1891
PAINE, SIDNEY B.	General Electric Co., 180 Summer St., Boston, Mass.	A June 8, 1887 M Nov. 1, 1887

Name.	Address.	Date of Membership.
PARKHURST, CHARLES D.	1st Lieut. 4th Artillery, U. S. Army, Fortress Monroe, Va.	A Dec. 21, 1892 M Nov. 15, 1893
PARKS, C. WELLMAN	1825 Fifth Ave., Troy, N. Y.	A July 12, 1887 M May 1, 1888
PARSHALL, H. F.	Electrical Engineer, British Thomson-Houston, Ltd., 38 Parliment St., Westminster, London, Eng.	A Sept. 7, 1888 M Mar. 18, 1890
PATTISON, FRANK A.	Firm of Pattison Bros, Consulting and Constructing Electrical Engineers, 136 Liberty St., New York City.	A Sept. 22, 1891 M Dec. 16, 1891
PEARSON, F. S.	Engineer, Room 841, 621 Broadway, New York City.	A Oct. 25, 1892 M Feb. 21, 1893
PERRINE, FREDERIC A. C., *D. Sc.*	Professor of Electrical Engineering, Leland Stanford, Jr., University, Palo Alto, Cal.	A Sept. 16, 1890 M Dec. 16, 1890
PERRY, NELSON W., *E. M.*,	Editor, *Electricity*, 6 Park Place, N. Y. City: residence, 18 Sidney Place, Brooklyn, N. Y.	A May 17, 1892 M Mar. 21, 1893
PHELPS, GEO. M.	(*Treasurer*). President, *Electrical Engineer*, 203 Broadway, New York.	A April 15, 1884 M Oct. 21, 1884
PICKERNELL, F. A.	Chief Engineer, Amer. Tel. & Tel. Co., 18 Cortlandt St., 153 Cedar St., New York City.	A Feb. 7, 1890 M Mar. 18, 1890
PIERCE, RICHARD H.	Pierce & Richardson, Electrical Engineers, 1409 and 1410 Manhattan Bldg., Chicago; residence, 5434 Monroe Ave., Hyde Park, Ill.	A April 18, 1893 M Dec. 20, 1893
PIKE, CLAYTON W., *B. S.*	Electrical Engineer, Falkenau Engineering Co., 1210 Betz Building, Philadelphia, Pa.	A Dec. 16, 1891 M Oct. 25, 1892
POPE, FRANKLIN L.	(*Past President*). Consulting Electrical Engineer and Expert, 39 Cortlandt St., N. Y.; residence, Great Barrington, Mass.	A April 15, 1884 M Oct. 21, 1884
PORTER, J. F.	Manager, Alton Electric Street Railroad Co., Alton, Ill.	A Sept. 6, 1887 M Nov. 1, 1887
PRATT, ROBERT J.	Electrician, Treas. and Mgr. Electric Mfg. Co. and Gas Engine Co., Greenbush, N. Y.	A July 12, 1887 M Sept. 6, 1887
RAE, FRANK B.	Electrical Engineer, Home Bank Building, Detroit, Mich.	A April 15, 1884 M Oct. 25, 1892
RAYMOND, CHAS. W.	[Address unknown,]	A June 8, 1887 M May 17, 1887
RECKENZAUN, FREDERICK.	Electrical Engineer, Box 225, 58 Demott St., West Hoboken, N. J.; 43 Wall St., New York City.	A Mar. 6, 1888 M June 5, 1888
REIST, HENRY G.	Designing Engineer, General Electric Co., 5 South Church St., Schenectady, N. Y.	A June 17, 1890 M Dec, 19, 1894
RICE, E. WILBUR, JR.	Technical Director, The General Electric Co., Schenectady, N. Y.	A Dec. 6, 1887 M Jan. 3, 1888

Name.	Address.	Date of Membership.
RIES, ELIAS E.	Electrical Engineer and Inventor, Prest. Ries Electric Specialty Co., Baltimore and Eutaw Sts.; residence, 430 South Broadway, Baltimore. Md.	A July 12, 1887 M Sept. 6, 1887
ROBB, WM. LISPENARD	Professor of Physics, Trinity College, Hartford, Conn.	A Dec. 16, 1891 M Mar. 15, 1892
ROBERTS, E. P.	E. P. Roberts & Co., Electrical and Mechanical Engineers, Brainard Block, Cleveland, O.	A Jan. 6, 1885 M Feb. 3, 1885
RODGERS, HOWARD S.	Electrical Engineer, Eddy Electric Mfg. Co., Windsor, Conn.	A Sept. 27, 1892 M May 16, 1893
ROHRER, ALBERT L.	Electrical Engineer, with General Electric Co., Schenectady, N. Y.	A Nov. 1, 1887 M May 1, 1888
ROSS, NORMAN	Electrical Engineer, Canadian General Electric Co., 65 Front St., Toronto, Ont.	A Sept 20, 1893 M Nov. 21, 1894
ROSS, ROBERT A.	Electrical Engineer, Royal Electric Co., 94 Queen St., Montreal, P. Q.	A Sept. 27, 1892 M April 18, 1893
ROUQUETTE, WILLIAM F. B.	Proprietor, Rouquette & Co., 47 Dey St., New York City.	A Mar. 21, 1894 M Dec. 19, 1894
SALOMONS, *Sir* DAVID LIONEL, *Bart. M. A.*, [Life Member.]	Engineer and Barrister, Broomhill, Tunbridge Wells, Kent, and 49 Grosvenor St., London, W. England.	A Feb. 7, 1888 M May 1, 1888
SANDS H. S.	Consulting and Constructing Electrical Engineer, Peabody Building, Wheeling, W. Va.	A Feb. 21, 1893 M Nov. 21. 1894
SARGENT, W. D.	General Manager, N. Y. & N. J. Tel. Co., 16 Smith St., Brooklyn, N. Y.	A April 15, 1884 M Feb. 21, 1894
SCOTT, CHARLES F.	Chief Electrician, Westinghouse Electric and Mfg. Co., Pittsburg, Pa.	A April 19, 1892 M Jan. 17, 1893
SHALLENBERGER, O. B.	Consulting Electrician, Westinghouse Electric and Mfg. Co., of Pittsburg; Rochester, Pa.	A Sept. 7, 1888 M Dec. 4, 1888
SHEA, DANIEL W.	Professor of Physics, University of Illinois. 403 W. Hill St., Champaign, Ill.	A Dec. 20, 1893 M June 20, 1894
SHELDON, SAMUEL, *A. M., Ph.D.*	Professor of Physics and Electrical Engineering. Polytechnic Institute, 170 State St., Brooklyn, N. Y.	A Dec. 16, 1890 M Oct. 27, 1891
SHEPARD, WM. E.	Steinway Railway Co., Long Island City, N. Y.	A Feb. 7, 1890 M Mar. 18, 1890
SLATER, HENRY B.	Vice-President and Manager, The Canon City Electric Light and Power Co., Canon City, Col.	A April 15, 1884 M Dec. 9, 1884
SMITH, FRANK STUART	Supt. Lamp Factory, Westinghouse Electric & Mfg. Co., Pittsburg, Pa.	A Sept. 27, 1892 M April 18, 1893

Name.	Address.	Date of Membership.
SMITH, JESSE M.	Consulting Electrical Engineer and Expert in Patent Causes, 36 Moffatt Block, Detroit, Mich.	A April 15, 1884 M June 26, 1891
SMITH, T. CARPENTER	Mechanical and Electrical Engineer, 212 Drexel Building, Philadelphia, Pa.	A Oct. 27, 1891 M Dec. 16, 1891
SPAULDING, HOLLON C.	Electrical and Mechanical Engineer, Nashua, N. H.	A April 21, 1891 M June 20, 1894
SPERRY, ELMER A.	Electrical Engineer, Sperry Electric Railway Co., Mason and Belden Sts., Cleveland, O.	A April 19, 1892 M Feb. 21, 1893
STANDFORD, WILLIAM	Asst. Supt. Telegraphs, Colonial Govt., Cape Town, Cape of Good Hope, Africa.	A Oct. 4, 1887 M Dec. 6, 1887
STEARNS, CHARLES K.	Electrical Engineer, Newton Centre, Mass.	A Aug. 6, 1889 M May 16, 1893
STEBBINS, THEODORE	Superintendent Railway Construction, General Electric Co., Schenectady, N. Y.	A July 9, 1889 M June 17, 1890
STEINMETZ, CHARLES P.	(*Manager*,) Electrician, General Electric Co., Schenectady, N. Y.	A Mar. 18, 1890 M April 21, 1891
STEVENS, W. LE CONTE	Professor of Physics, Rensselaer Polytechnic Institute, Troy, N. Y.	A Dec. 20, 1893 M June 20, 1894
STIERINGER, LUTHER	Electrical Expert, Morris Building, 68 Broad St.; residence, 1873 Lexington Ave., New York.	A June 8, 1887 M Nov. 1, 1887
STILLWELL, LEWIS B.	Electrical Engineer, Westinghouse Electric and M'f'g Co., Pittsburg, Pa.	A April 19, 1892 M Nov. 15, 1892
TAINTOR, GILES	Division Sup't. Western Division New England Telephone and Telegraph Co., Springfield, Mass.	A June 26, 1891 M Dec. 16, 1891
TALTAVALL, THOS. R.	Editor, *Electric Age*, World Building, New York City.	A Jan. 20, 1891 M Oct. 27, 1891
TERRY, CHARLES A.	Lawyer, Westinghouse Electric and Mfg. Co., 120 Broadway, New York City.	A April 5, 1887 M May 17, 1887
THOMAS, BENJAMIN F., *Ph. D.*	Professor of Physics, Ohio State University, Columbus, O.	A June 7, 1892 M Nov. 15, 1892
THOMSON, PROF. ELIHU	(*Past President*). Electrician, General Electric, and Thomson Electric Welding Companies, Lynn, Mass.	A April 15, 1884 M April 21, 1891
THOMPSON, EDWARD P.	Consulting Electrician and Patent Attorney in Electrical Cases, 5 Beekman St., New York City.	A April 15, 1884 M Dec. 3, 1889
THURNAUER, ERNST	Manager, Thomson-Houston International Elec. Co., 27 Rue de Loudres, Paris, France.	A Oct. 14, 1887 M Dec. 6, 1887
TISCHENDOERFER, F. W.	Electrical Engineer, Schückert & Co., Nuremberg, Germany.	A April 19, 1892 M Nov. 21, 1894

Name.	Address.	Date of Membership.
TRAFFORD, EDWARD W.	Electrical Engineer, Richmond Railway and Electric Co., 104 N. 7th St., Richmond, Va.	A Feb. 21, 1894 M Dec. 19, 1894
TURNER, WILLIAM S.	President, Woodbridge & Turner Engineering Co., 47 Times Building, New York City.	A Dec. 7, 1886 M Oct. 2, 1888
UEBELACKER, CHAS. F.	Electrical Engineer, 88 Avenue C., Bayonne, N. J.	A Feb. 7, 1890 M Nov. 15, 1893
UHLENHAUT, FRITZ, JR.	Philadelphia Traction Co., 4101 Haverford St., Philadelphia, Pa.	A May 7, 1889 M Dec. 19, 1894
UPTON, FRANCIS R.	General Manager, Edison Lamp Works, Harrison, N. J.; residence, 107 Day St., Orange, N. J.	A May 17, 1887 M Mar. 15, 1892
VAIL, J. H.	President and Chief Engineer, Electrical and Mechanical Engineering and Trading Co., 39 Cortlandt St., New York City.	A June 8, 1887 M Nov. 1, 1887
VANSIZE, WILLIAM B.	(*Manager.*) Solicitor of Patents and Expert, 44 Broad St., New York City.	A April 15, 1884 M Oct. 21, 1884
VAN TRUMP, C. REGINALD	Engineer and Manager, Wilmington, City Electric Co., Wilmington, Del.	A Feb. 5, 1886 M Feb 21, 1894
WADDELL, MONTGOMERY	Engineer, The Waddell-Entz Electric Co., Bridgeport, Conn.	A Feb. 7, 1888 M May 1, 1888
WAIT, HENRY H.	Assistant Electrical Engineer, Western Electric Co., 4919 Madison Ave., Chicago, Ill.	A Sept. 20, 1893 M June 20, 1894
WALDO, DR. LEONARD	Electrical Engineer, Secretary, The Waldo Foundry, and Member Firm of Sprague, Duncan, & Hutchinson (Ltd.), 57 Coleman St., Bridgeport, Conn.	A June 5, 1888 M Dec. 4, 1888
WALKER, SYDNEY F.	Electrical Engineer, 195 Severn Road, Cardiff, Wales.	A June 2, 1885 M May 17, 1887
WARNER, ERNEST P.	Electrical Engineer, Western Electric Co., 227 So. Clinton St., Chicago, Ill.	A Sept. 20, 1893 M June 20, 1894
WATERMAN, F. N.	Electrical Engineer, Westinghouse Electric and Mfg. Co., 120 Broadway, New York City.	A Feb. 21, 1893 M June 20, 1894
WEAVER, W. D.	(*Manager.*) 7 West 26th St., New York City.	A May 17, 1887 M May 17, 1887
WEBB, HERBERT LAWS	(*Manager*) 18 Cortlandt St.; residence, 126 East 19th St., New York City.	A Oct. 21, 1890 M Dec. 16, 1890
WEEKS, EDWIN R.	Rooms 301 to 303, National Bank of Kansas City Building, Kansas City, Mo.	A Sept. 6, 1887 M Nov. 1, 1887
WELLER, HARRY W.	Electrical Engineer, The Woodlands, Jamaica, N. Y.	A Oct. 21, 1890 M Nov. 24, 1891

Name.	Address.	Date of Membership.
WELLS, DOUGLAS	Hurstfield, The Avenue, Gipsy Hill, London, Eng.	A June 7, 1892 M Jan. 17, 1893
WESTON, EDWARD	(*Past President.*) Vice-President Weston Electrical Instrument Co., 120 William St., and 645 High St., Newark, N. J.	A April 15, 1884 M Oct. 21, 1884
WETZLER, JOSEPH	Editor *The Electrical Engineer*, 203 Broadway, New York City.	A April 15, 1884 M Dec. 9, 1884
WHARTON, CHAS. J.	82 Bond St., London, Eng.	A Jan. 3, 1888 M May 1, 1888
WHEELER, SCHUYLER S., [Life Member.]	*Sc.D.* President, Crocker-Wheeler Electric Co., 39 Cortlandt St., and Ampere, N. J.; residence, 34 Gramercy Park, New York City.	A June 2, 1885 M Sept. 1, 1885
WIENER, ALFRED E.	Electrical and Mechanical Engineer; residence, 208 Liberty St., Schenectady, N. Y.	A May 16, 1893 M May 15, 1894
WILKES, GILBERT	Consulting Electrical Engineer, 149 Griswold St., Detroit, Mich.	A Jan. 7, 1890 M Mar. 18, 1890
WILLYOUNG, ELMER G.	Secretary and Treasurer, Falkenau Engineering Co., Ltd., 1210 Betz Building, Philadelphia.	A Nov. 24, 1891 M Dec. 20, 1893
WILSON, CHARLES H.	Monadnock Building, Chicago, Ill.	A Nov. 24, 1891 M Feb. 16, 1892
WILSON, FREMONT	Electrician, 108 Fulton St., and 2153 Seventh Ave., New York City.	A Mar. 6, 1888 M June 5, 1888
WILSON, HARRY C.	Supt. of P. O. Telegraph with the Government, Kingston, Jamaica, West Indies	A Jan. 19, 1891 M June 7, 1892
WINCHESTER, A. E.	Consulting Engineer and Designer of Electric Systems, South Norwalk, Conn.	A June 8, 1887 M Nov. 1, 1887
WIRT, CHARLES	(*Manager.*) Consulting Engineer and Proprietor, The Wirt Laboratory, 56 Fifth Ave., Chicago, Ill.	A Sept. 8, 1888 M June 20, 1894
WOLCOTT, TOWNSEND	Electrician, 1002 Bennett Building, New York City.	A Mar. 6, 1888 M Dec. 16, 1890
WOLVERTON, B. C.	Electrician, N. Y. & Pa. Telephone and Telegraph Co., Elmira, N. Y.	A Mar. 18, 1890 M Feb. 21, 1895
WOODBRIDGE, J. L.	Secretary and Treasurer, Woodbridge & Turner Engineering Co., 47 Times Building, New York City.	A June 8, 1887 M Nov. 1, 1887
WRIGHT, PETER	Inspector of Electrical Works, United Gas Improvement Co., 807 Drexel Bldg, Philadelphia, Pa.	A May 16, 1889 M Jan. 16, 1895
WURTS, ALEXANDER JAY	Electrical Expert, Westinghouse Electric & Mfg. Co., Pittsburg, Pa.	A April 19, 1892 M Nov. 15, 1892
YOUNG, C. GRIFFITH	Electrical Engineer, White-Crosby Co., 706 Equitable Building, Baltimore, Md.	A Jan. 3, 1889 M April 21, 1891

Members, - - - - 268.

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
ADAMS, COMFORT A., JR.	Instructor in Electrical Engineering, Harvard University 21 Stoughton Hall, Cambridge, Mass.	Jan. 17, 1894
AGNEW, CORNELIUS R.	Electrical Engineer, Kinsman Block System Co., 23 West 39th St., New York City.	Mar. 21, 1894
ALBANESE, G. SACCO	Compagnie Internationale d'Electricite, Liege, Belgium.	Sept. 20, 1893
ALBERT, HENRY	Key West, Fla.	Feb. 21, 1893
ALDEN, JAMES S.	Assistant Manager, with L. H. Alden, 486 River Drive, Passaic, N. J.	May 19, 1891
ALDRICH, WILLIAM S.	Professor of Mechanical Engineering and Director Mechanical Arts, West Virginia University. P. O. Box 256, Morgantown, W. Va.	Mar. 15, 1892
ALEXANDER, HARRY	Electrical Engineer, General Manager and Vice Prest. Alexander-Chamberlain Electric Co., 126 Liberty, and 348 W. 145th St., New York City.	April 21, 1891
ALEXANDER, P. H.	Manager, Lighting Dept., Electric Selector and Signal Co., 45 Broadway, New York City.	Dec. 16, 1890
ANDERSON, HENRY S.	General Manager and Electrician, United Electric Light Co., Springfield, Mass.	Jan. 16, 1895
ANDERSON, W. F.	Professor of Physics and Electrical Engineering, Pacific Building, Washington, D C.	Sept. 20, 1893
ANDREWS, WM. S.	General Electric Co., Schenectady, N. Y.	Mar. 5, 1889
ANTHONY, WATSON G.	Electrician, 32½ Webster St., Newark, N. J.	Feb. 24, 1891
ARCHBOLD, WM. K.	Westinghouse Electric and Mfg. Co. 620 Atlantic Ave., Boston, Mass.	June 20, 1894
ARCHER, GEO. F.	Student in Electrical Engineering, Columbia College; Residence, Garden City, L. I.	Nov. 21, 1894
ARMSTRONG, CHAS. G.	Electrical Expert, 1300 Auditorium Tower, Chicago, Ill.	Sept. 27, 1892
ARNOLD, CRAIG R.	Electrician and Treasurer, Arnold Electric Co., Chester and Sharon Hill, Pa.	Nov. 15, 1892
ASHLEY, FRANK M.	Master Mechanic, Ashley Engineering Works, Hawthorne, N. J., 136 Liberty St., N. Y.	Nov. 21, 1894
ATWOOD, GEORGE F.	Mechanic and Lawrence Sts., Newark, N. J.	Sept. 16, 1890
AUERBACHER, LOUIS J.	Secretary and General Manager, Automatic Electrical Specialty Co., 136 Liberty St., New York City.	Sept. 20, 1893
BABCOCK, CLIFFORD D.	Rome, Kanawha Co., W. Va.	Feb. 21, 1894
BADT, LIEUT. FRANCIS B.	Electrical Engineer, Siemens & Halske Electric Co. of America, 1215 Monadnock Block, 6506 Lafayette Ave., (Englewood), Chicago, Ill.	April 19, 1893

Name.	Address.	Date of Election.
BARBOUR, FRED FISKE	Manager, Power and Mining Department, Pacific District, General Electric Co., 15 First St., San Francisco, Cal.	May 16, 1893
BARNARD, JOHN H.	Vice-President and General Manager, Wilmington Street Railway Co., Wilmington, N. C.	June 26, 1891
BARNES, EDWARD A.	Electrical Expert, Fort Wayne Electric Co., Fort Wayne, Ind.	Sept. 20, 1893
BARSTOW, WILLIAM S.	General Supt., Edison Electric Illuminating Co., 360 Pearl St., Brooklyn, N. Y.	Feb. 21, 1894
BARTH-BARTOSHEVITCH, A.	Mechanical and Electrical Engineer, [Address unknown.]	May 16, 1893
BARTLETT, EDWARD E.	Member Firm Bartlett & Co., 23 Rose St., New York City.	June 6, 1893
BARTON, ENOS M.	President Western Electric Co., 227 South Clinton St., Chicago, Ill.	July 12, 1887
BARRETT, JOHN A.	Elektron Mfg. Co., 126 Liberty Street, New York City.	June 8, 1887
BATES, FREDERICK C.	Electrical Engineer, Union Elektricitäts Gesellschaft, Berlin, Germany.	Jan. 20, 1891
BAUER, W. F.	Electrician, 313 High St., Newark, N. J.	April 15, 1890
BEATTIE, JOHN, JR.	Manager and Superintendent, The Beattie Battery, Zinc and Electric Co., Fall River, Mass.	Sept. 6, 1887
BEDELL, DR. FREDERICK,	Assistant Professor in Physics, Cornell University, Ithaca, N. Y.	April 21, 1891
BENNETT, EDWIN H., JR.	Electrician and Engineer, Diehl & Co., Elizabethport, N. J., and 17 E. 33d St., Bayonne, N. J.	June 20, 1894
BENNETT, JOHN C.	Electrician, General Electric Co., Box 3067, 44 Broad St., New York City.	Mar. 18, 1890
BENTLEY, MERTON H.	Chicago Telephone Co.; residence, 221 Scoville Ave., Oak Park, Ill.	Oct. 18, 1893
BERG, ERNST JULIUS	Engineer, General Electric Co.; residence, 53 Washington Ave., Schenectady, N. Y.	Sept. 19, 1894
BERGHOLTZ, HERMAN	Secretary and Treasurer, Ithaca Street Railway Co., Ithaca, N. Y.	April 2, 1889
BERLINER, EMILE	Inventor, Columbia Road, between Fourteenth and Fifteenth Sts., Washington, D. C.	April 15, 1884
BERRESFORD, ARTHUR W.,	*B. S., M. E.* Electrician, Brooklyn City R. R. Co., 197 Van Buren St., Brooklyn, N. Y.	May 15, 1894
BERTHOLD, VICTOR M.	Patent Department, American Bell Telephone Co., 125 Milk St., Boston; residence, 16 Upton St., Cambridgeport, Mass.	May 17, 1892

Name.	Address.	Date of Election.
BEST, A. T.	Electrical Engineer, St. Augustine, Florida.	Feb. 21, 1894
BETHELL, U. N.	Acting General Manager, The Metropolitan Telephone and Telegraph Co., 18 Cortlandt St., N. Y. City.	Jan. 17, 1894
BIJUR, JOSEPH	Student in Electrical Engineering, Columbia College, residence, 41 West 53d St., New York City.	May 15, 1894
BILLBERG, C. O. C.	Electrical Engineer, Thomas H. Dallett & Co., 3200 Arch St., Philadelphia, Pa.	Mar. 21, 1894
BLACK, CHAS. N.	Brush Electric Co., Belden St., Cleveland, O.	Feb. 7, 1890
BLADES, HARRY H.	General Superintendent, The Detroit Motor Co., 1343-55 Cass Ave., Detroit, Mich.	April 19, 1892
BLAKE, HENRY W.	Editor, *Street Railway Journal*, 26 Cortlandt St., New York City.	Nov. 13, 1888
BLAKE, THEODORE W.	Electrician, National India Rubber Co., Bristol, R. I.	Sept. 20, 1893
BLANCHARD, CHARLES M.	1209 Betz Building, Philadelphia, Pa.; residence, 5113 Pulaski Ave., Germantown, Pa.	Sept. 19, 1894
BLISS, DONALD M.	Electrician, Holtzer-Cabot Electric Co., 1 Davis Court, Washington St., Brookline, Mass.	Feb. 7, 1890
BLISS, GEORGE S.	Electrical Engineer, Central District and Printing Telegraph Co., Telephone Bldg., Pittsburg, Pa.	June 20, 1894
BLISS, WM. J. A.	820 Connecticut Ave., Washington, D. C.	Jan. 20, 1891
BLISS, WILLIAM L., *B. S., M. E.*	Electrical Engineer, Riker Electric Motor Co., 24 Irving Place, Brooklyn, N. Y.	Mar. 21, 1894
BLIZARD, CHARLES	Sales Agent. Electric Storage Battery Co., 66 Broadway; residence, Passaic, N. J.	Nov. 21, 1894
BLOOD, JOHN B.	Assistant Engineer, Railway Dept., General Electric Co., Schenectady, N. Y.	June 20, 1894
BLOOD, W. HENRY JR.	The Franklin Electric Co., 535 Delaware St., Kansas City, Mo.	April 2, 1889
BOARDMAN, HARRY B.	Wisconsin Telephone Co., 1530 Grand Ave., Milwaukee, Wis.	Sept. 20, 1893
BOGART, A. LIVINGSTON	Electrical and Patent Expert, 22 Union Square, New York City.	July 10, 1888
BOGGS, LEMUEL STEARNS	Lafayette, Ind.	Sept. 20, 1893
BOGUE, CHARLES J.	Manufacturer and Dealer in Electrical Supplies, 206 Centre St., N.Y. City.	Dec. 3, 1889
BOHM, LUDWIG K., *Ph.D.*,	Consulting Electrical and Chemical Expert, 117 Nassau St., N. Y. City.	Nov. 15, 1892

Name.	Address.	Date of Election.
BOILEAU, WILLIAM E.	Superintendent and Electrician, Brush Electric Light & Power Co., Columbus, Ga.	Sept. 19, 1894
BOTTOMLEY, HARRY	Electrical Engineer, Supt., Marlboro Electric Co., Marlboro, Mass.	April 2, 1889
BOUGHAN, EDWARD L.	Supply Agent, American Telephone and Telegraph Co., 153 Cedar St., New York City.	Dec. 21, 1892
BRACKETT, PROF. CYRUS F.	Princeton, N. J.	April 15, 1889
BRADDELL, ALFRED E.	Electrical Inspector, Underwriters' Association, Middle Department, 316 Walnut St., Philadelphia, Pa.	Sept. 1, 1890
BRADY, E. D. A.	Consulting and Constructing Engineer, Lock P. O. Box 132, Waterbury, Conn.	Sept. 19, 1894
BRADY, FRANK W.	Electrical Engineer, Wellsburg, W. Va.	June 20, 1894
BRADY, PAUL T.	Manager, Central N. Y. Agency, Westinghouse Electric and Mfg. Co., Syracuse, N. Y.	July 12, 1887
BRAGG, CHARLES A.	Manager Phila. Agency, Westinghouse Electric and Mfg. Co., 302 Girard Building, Philadelphia, Pa.	Sept. 20, 1893
BREITHAUPT, E. CARL	Electrical Engineer, Berlin, Ont.	June 6, 1893
BRIXEY, W. R.	Proprietor and Manufacturer, Day's Kerite Wire and Cables, 203 Broadway, New York City.	Sept. 20, 1893
BROICH, JOSEPH	Superintendent and Electrician, with F. Pearce, New York City; residence, 448 8th Ave., Brooklyn, N. Y.	Jan. 17, 1894
BROPHY, WILLIAM	17 Egleston St., Jamaica Plain, Mass.	Mar. 5, 1889
BROWN, ALEX. S.	Electrical Engineer, 397 St. Nicholas Ave., New York City.	Jan. 7, 1890
BROWN, CHARLES A.	Attorney, Firm of Barton & Brown, Attorneys and Counsellors, 1428–1430 Monadnock Building, Chicago, Ill.	July 12, 1887
BROWN, EDWARD D.	District Inspector, American Telephone and Telegraph Co., 18 Cortlandt St., New York City; residence, 75 Hicks St., Brooklyn, N. Y.	Sept. 19, 1894
BRYANT, WALDO C.	Manager and Treasurer, The Bryant Electric Co., Bridgeport, Conn.	May 16, 1893
BUBERT, J. F.	Supervising and Contracting Electrical Engineer, 620 Atlantic Ave., Boston, Mass.	June 7, 1892
BUCKINGHAM, CHAS. L.	Patent Attorney, Western Union Telegraph Co., 195 Broadway, P. O. Box 856, New York City.	April 15, 1884
BUNCE, THEODORE D.	The Storage Battery Supply Co., 239 E. 27th St., New York City.	May 20, 1890

Name.	Address.	Date of Election.
BURKE, JAMES	Firm of Herrick & Burke, 203 Broadway, New York City.	May 16, 1893
BURNETT, DOUGLAS, *B.S.*	Edison Illuminating Co , Inspection Dept., 55 Duane St., New York City; residence, 42 Livingston St., Brooklyn, N. Y.	Feb. 21, 1893
BURTON, GEO. D.	Electrician and President, Electrical Forging Co., 194 Washington St., Boston, Mass.	April 21, 1891
BURTON, WILLIAM C.	With White-Crosby Co., Equitable Bldg. Baltimore, Md.	Sept. 20, 1893
BUTLER, WILLIAM C.	Monte Cristo Mining Co., Everett, Washington.	Mar. 21, 1893
BUYS, ALBERT	Electrical Engineer, Rutherford, N. J.	Feb. 7, 1890
CABOT, JOHN ALFRED	City Electrician, 123 W. 8th St., Cincinnati, O.	May 16, 1893
CALDWELL, EDWARD	*Street Railway Journal*, Havemeyer Bldg., New York City.	Jan. 20, 1891
CALDWELL, FORDYCE S.	Proprietor Western Electric Construction Co., 503 Delaware St., Kansas City, Mo.; residence, 151 Henry St., Brooklyn, N. Y.	Sept. 22, 1891
CALDWELL, FRANCIS C.	Assistant Professor of Electrical Engineering, Ohio State University, Columbus, O.	June 20, 1894
CALLENDER, ROMAINE	Electrician, Decker Building, New York City.	Sept. 27, 1892
CANFIELD, MILTON C.	Electrical Engineer, 18 Clinton St., Cleveland, O.	Feb. 21, 1893
CAPUCCIO, MARIO	Electrical Engineer, Piazza Statuto 15, Corino, Italy.	Dec. 20, 1893
CARICHOFF, E. R.	Electrical Engineer. Sprague Electric Elevator Co., Postal Tel. Bldg., 253 Broadway, New York City.	Mar. 21, 1894
CARSON, DAVID I.	Secy. and Gen. Supt., The Southern Bell Telephone and Telegraph Co., 18 Cortlandt St., New York City.	Dec. 21, 1892
CARTWRIGHT, FRED'K G.	Electrical Engineer and Agent, Fort Wayne Electric Co., 41 and 43 Stevenson St., San Francisco, Cal.	Sept. 22, 1891
CARTY, J. J.	(*Manager*) Engineer, Metropolitan Telephone and Telegraph Co., 18 Cortlandt St., New York City.	April 15, 1890
CARUS-WILSON, CHARLES A.	Professor of Electrical Engineering, McGill University, Montreal, P. Q.	April 18, 1894
CASE, WILLARD E.	6 Fort St., Auburn, N. Y.	Feb. 7, 1888
CASPER, LOUIS	Electricial Engineer and Contractor, 307 New Ridge Bldg., Kansas City, Mo.	April 21, 1891
CHADBOURNE, HENRY R., JR.	Electrical Engineer, Troy City Ry. Co., Troy, N. Y.	May 15, 1894

Name.	Address.	Date of Election.
CHAMBERLAIN, F. H.	Electrician, Metropolitan R. R. Co., 2411 P St., N. W. Washington, D. C.	June 17, 1890
CHASE, HARVEY STUART	Mechanical and Electrical Engineer, 136 Liberty St., New York City.	Sept. 19, 1894
CHENEY, FREDERICK A.	Secretary, Treasurer, and General Manager, The Elmira Illuminating Co., Elmira, N. Y.	Oct. 1, 1889
CHERMONT, ANTONIO LEITE	Box 253, Para, U. S. Brazil.	Mar. 18, 1890
CHESNEY, C. C.	Electrician, Stanley Laboratory, Pittsfield, Mass.	June 20, 1894
CHILDS, ARTHUR EDWARDS, *B. Sc. M.E E.E.*	Electrical Engineer, Westinghouse Elec. and Mfg. Co., 302 Girard Bldg., Philadelphia, Pa.	June 20, 1894
CHILDS, SUMNER W.	Columbus Central Railway Co., Columbus, O.	May 15, 1894
CHILDS, WALTER H.	Brattleboro, Vt.	Sept. 6, 1887
CHINNOCK, C. E.	137 Sixth Ave., Brooklyn, N. Y.	April 15, 1884
CHUBBUCK, H. EUGENE	Electrical Engineer, Pueblo, Col.	Dec. 4, 1888
CLAFLIN, ADAMS D.	President, Perkins Lamp Co., and of Claflin & Kimball, (Inc.), Electrical Contractors, Room 53, 110 Boylston St., Boston; residence, Newton Centre, Mass.	June 7, 1892
CLARK, LEROY, JR.	Electrician, Safety Insulated Wire and Cable Co., 229 West 28th St., residence, 350 West 30th St., New York City.	May 15, 1894
CLEMENT, LEWIS M.	1013 Central Ave., Oakland, Cal.	April 21, 1891
CLEVELAND, WM. B.	[Address unknown.]	April 15, 1884
CLOUGH, ALBERT L.	Box 114, Manchester, N. H.	Feb. 21, 1894
COBB, JOHN S.	[Address unknown.]	June 17, 1890
COFFIN, CHAS. A.	General Electric Co., 620 Atlantic Ave., Boston, Mass.	Dec. 6, 1887
COGSWELL, A. R.	Electrician and Superintendent, Halifax Illuminating and Motor Co., Ltd., 34 Bishop St., Halifax, N. S.	April 21, 1891
COHO, HERBERT B.	H. B. Coho & Co., Electrical Engineers, 203 Broadway, New York City.	Mar. 21, 1894
COLGATE, GEO. L.	Electrical Engineer, 136 Liberty St., New York City.	June 17, 1890
COLLEY, BENJAMIN W.	First Ass't. Superintendent, The Commercial Cable Co., Hazel Hill, N. S.	Oct. 21, 1890
COLVILLE, FRANK C.	Electrician and Inventor, 1503 Seventh Ave., Oakland, Cal.	May 19, 1891
COLVIN, FRANK R.	President, Interior Telephone Co., 203 Broadway, New York City.	April 18, 1894

Name.	Address.	Date of Election.
COMPTON, ALFRED G.	Professor of Applied Mathematics, College of the City of New York, 17 Lexington Ave., New York City.	Nov. 1, 1887
COMSTOCK, LOUIS K.	Monadnock Building, Chicago, Ill.	Dec. 20, 1893
COOLIDGE, CHARLES A.	Electrical Engineer, Superintendent, Northern Improvement Co., 591 Hood St., Portland, Ore.	April 19, 1892
COREY, FRED. B.	Consulting Engineer, 114 Chandler St., Boston, Mass.	Dec. 20, 1893
CORNELL, CHAS. L.	Electrical Engineer, Hamilton, O.	Feb. 7 1890
CORSON, WILLIAM R. C.	Assistant Electrical Engineer, The Eddy Electric Mfg. Co., Windsor, Conn.	Jan. 17, 1893
CORY, CLARENCE L.	Professor of Electrical Engineering, University of California, Berkeley, Cal.	April 19, 1892
CRAIG, J. HALLY	Cumner, Craig & Co., 69 Broad St., Boston, Mass.	May 16, 1893
CRANDALL, CHESTER D.	Assistant Treasurer, Western Electric Co., 227 South Clinton St., Residence, 4438 Ellis Ave. Chicago, Ill.	Sept. 27, 1892
CRANE, W. F. D.	Manager Electrical Department H. W. Johns Manufacturing Co., 87 Maiden Lane, New York City; residence, 24 Halstead Pl., East Orange, N. J.	Feb. 7, 1888
CREAGHEAD, THOMAS J.	President and General Manager, Creaghead Engineering Co., 296 Plum St., Cincinnati, O.	Sept. 20, 1893
CREHORE, ALBERT C., *Ph.D.*	Assistant Professor of Physics, Dartmouth College, Hanover, N. H.	Dec. 21, 1892
CREWS, J. W.	Manager, Southern Bell Telephone and Telegraph Co., Telephone Exchange, Norfolk, Va.	Sept. 19, 1894
CRIGGAL, JOHN E.	Electrician, Davis Electrical Works, 143 Tenth St., Springfield, Mass.	June 20, 1894
CROSBY, JAMES W.	Electrical Engineer, 38 Bedford St., Boston; residence, Wellington, Mass.	Feb. 21, 1894
CROSBY, OSCAR T.	White-Crosby Co., 29 Broadway, New York City.	Mar. 18, 1890
CROXTON, A. L.	Electrical Engineer, Standard Electric Co., 7118 Drexel Ave., Chicago, Ill.	June 20, 1894
CUNTZ, JOHANNES H.	Assistant to President Henry Morton, Stevens Institute of Technology, 325 Hudson St., Hoboken, N. J.	Mar. 5, 1889
CURTIS, CHAS. G.	President, Curtis Electric Mfg. Co., Pacific Ave., Jersey City, N. J.	April 15, 1884
CUSHING, F. W.	Electrical Engineer, 1106 The Rookery, Chicago, Ill.	Nov. 24, 1891

Name.	Address.	Date of Election.
CUSHING, HARRY COOKE, JR.	Electrical Inspector, Boston Board of Fire Underwriters, 55 Kilby St.; Residence, 259 Beacon St., Boston, Mass.	Sept. 19, 1894
CUSHMAN, HOLBROOK	Instructor in Physics, Columbia College, 337 West 22d St., New York City.	June 5, 1888
DACUNHA, MANOEL IGNACIO	Manager of the Electrical Section, Emprera Industrial Gram-Para, Para, U. S. of Brazil.	May 16, 1893
DAME, FRANK L.	Engineer, General Electric Co., Portland, Ore.	June 26, 1891
DANA, R. K.	Agent, Washburn and Moen Mfg. Co., 16 Cliff St., New York City.	April 15, 1884
DARLINGTON, FREDERIC W.	Consulting Electrical and Mechanical Engineer, 503 Girard Building, Philadelphia, Pa.	Sept. 19, 1894
DAVENPORT, C. G.	Expert and Agent, General Electric Co., 44 Broad St., New York City.	Nov. 21, 1891
DAVENPORT, GEORGE W.	61 Ames Bldg., Boston, Mass.	June 4, 1889
DAVIDSON, EDW. C.	Patent Lawyer, Room 179 Times Bldg., New York City.	Feb. 7, 1890
DAVIS, DELAMORE L.	Superintendent, Salem Electric Light and Power Co., 299 Lincoln Ave., Salem, O.	April 2, 1889
DAVIS, JOSEPH P.	Engineer, American Bell Telephone Co., 113 W. 38th St., New York City.	April 15, 1884
DECKER, DELBERT H.	Solicitor of Patents, with H. C. Townsend, 5 Beekman St., New York City.	Sept. 20, 1893
DEKHOTINSKY, CAPT. ACHILLES.	Late Chief Electrician and Torpedo Officer, Imperial Russian Navy, Marlboro, Mass.	Oct. 27, 1891
DELANCEY, DARRAGH	Manager of Kodak Park Works, Eastman Kodak Co., Rochester, N. Y.	Sept. 19, 1894
DELAND, FRED	Publisher, *Electrical Engineering*, 436 The Rookery, Chicago, Ill.	Feb. 16, 1892
DENISON, SYLVESTER P.	143 Centre St., New York City; residence, Belleville, N. J.	Jan. 16, 1895
DENTON, JAMES E.	Professor of Experimental Mechanics, Stevens Institute of Technology, Hoboken, N. J.	July 12, 1887
DESMOND, JERE. A.	Electrical Engineer, Kingston, N. Y.	Jan. 19, 1892
DEY, HARRY E.	342 Tenth St., Brooklyn, N. Y.	Dec. 19, 1894
DICKERSON, E. N.	Attorney-at-Law, 64 E. 34th St., New York City.	April 15, 1884
DOANE, S. EVERETT	68 Park Pl., Newark, N. J.	Aug. 6, 1889
DOBBIE, ROBERT S.	Electrical Engineer, 43 Wellington Park, Clifton, Bristol, Eng.	Feb. 5, 1889

Name.	Address.	Date of Election.
DODGE, PROF. OMENZO G.	U. S. Navy, Navy Dep't, Washington, D. C.	Sept. 20, 1893
DOMMERQUE, FRANZ J.	Chief Draughtsman, Chicago Telephone Co.; residence, 71 Potomac Ave., Chicago, Ill.	Oct. 17, 1894
DOOLITTLE, CLARENCE E.	Manager and Electrician, Roaring Fork Electric Light and Power Co., Aspen, Colo.	May 15, 1894
DOOLITTLE, THOMAS B.	Engineering Department, American Bell Telephone Co., 125 Milk St., Boston, Mass.	May 16, 1893
DOREMUS, CHARLES A.	*M.D. Ph.D.* 59 W. 51st St., New York City.	July 7, 1884
DORR, FRANK H.	Electrical Engineer, General Electric Co., Monadnock Building, Chicago, Ill.	May 15, 1894
DOW, ALEX	Engineer, Public Lighting Commission, Detroit, Mich.	Sept. 20, 1893
DRESSLER, CHARLES E.	17 Lexington Ave., New York City.	Dec 16, 1890
DRYSDALE, WILLIAM A.	Consulting Electrical Engineer, Hale Building, Philadelphia, Pa.	Sept. 19, 1894
DUNCAN, THOMAS	Electrician, Laboratory Fort Wayne Electric Corporation, 407 Broadway, Fort Wayne, Ind.	Oct. 17, 1894
DUNN, KINGSLEY G.	Electrician. Care of *Pacific Electrician*, San Francisco, Cal.	Oct. 17, 1894
DURANT, EDWARD	Electrician, Gas Engine Plants for Electric Light and Heat, 39 Cortlandt St.; residence, 115 East 26th St., New York City.	Nov. 15, 1892
DURANT, GEO. F.	Vice-Pres't Bell Telephone Co., of Mo., 511 No. 4th St., St. Louis, Mo.	April 15, 1884
DYER, FRANCIS MARON	Associate Engineer with Chas. L. Eidlitz, 10 West 23d St ; residence, 355 Lenox Ave., New York City.	Sept. 19, 1894
EDDY, H. C.	Salesman, Western Electric Co., Room 22, 170 La Salle St., Chicago, Ill.	June 20, 1894
EDEN, MORTON EDWARD	Electrical Inspector, Western District the Underwriters' Association of the Middle Department, Philadelphia, Pa.; residence, 83 Fourth Ave., Pittsburg, Pa.	Sept. 19, 1894
EDWARDS, JAMES P.	Electrical Engineer, 1569 Walton Way, Augusta, Ga.	April 19, 1892
EGLIN, WM. C. L.	Chief of Electrical Department, Edison Electric Light Co., 909 Walnut St.; residence, 4230 Chester Ave., Philadelphia, Pa.	Sept. 19, 1893
EIDLITZ, CHAS. L.	10 West 23d St.; residence, 1125 Madison Ave., New York City.	Sept. 19, 1894
EKSTROM, AXEL	Electrical Engineer, General Electric Co.; residence, 92 Hamilton Ave., Lynn, Mass.	June 17, 1890

Name.	Address.	Date of Election.
ELEY, HARRIS H.	Electrical Workshop Supt. W. C. & S. W. Telephone Co., 88 Colston St., Bristol, Eng.	Jan. 7, 1890
ELLICOTT, EDWARD B.	Superintendent of Construction, Western Electric Co., 4438 Ellis Ave., Chicago, Ill.	Sept. 19, 1894
ELMER, WILLIAM, JR.	Firm of Elmer & Hall, Consulting and Contracting Electrical Engineers, 25-26 Forst-Richey Building, Trenton, N. J.	Mar. 18, 1890
ELY, WM. GROSVENOR, JR.	239 5th St., Niagara Falls, N. Y.	Mar. 21, 1893
EMMET, HERMAN L. R.	Publisher and Printer, 36 Cortlandt St., New York City.	April 15, 1884
ENTZ, JUSTUS B.	Electrical Engineer, Accumulatoren Fabrik, Hagen, Westphalia, Germany.	Jan. 7, 1890
ESSICK, SAMUEL V.	Electrician, The Essick Printing Tel. Co., Yonkers, N. Y.	May 19, 1891
ETHERIDGE, CHAS. LOCKE	Chicago Telephone Co.; residence, 4714 Kenwood Ave., Chicago, Ill.	Oct. 17, 1894
ETHERIDGE, E. L.	Electrician, with Equipment Dep't, Navy Yard; residence, 66 No. Oxford St., Brooklyn, N. Y.	Dec. 20, 1893
EYRE, M. K.	Assistant to Manager of Lamp Sales, General Electric Co., Harrison, N. J.	Oct. 17, 1894
FARNSWORTH, ARTHUR J.	Chief Engineer, Larchmont Electric Co., Mamaroneck, N. Y.	Jan. 16, 1895
FAY, THOMAS J.	"C. & C." Electric Co., 143 Liberty St., New York City.	June 26, 1891
FIELDING, FRANK E. [Life Member.]	Chemist and Assayer, Virginia City, Nev.	Sept. 6, 1887
FISCHER, GUSTAVE J.	Engineer for Tramway Construction, Public Works Department, Sydney, N. S. W.	Jan. 20, 1891
FISH, WALTER C.	General Electric Co., Lynn, Mass.	June 26, 1891
FISHER, HENRY W.	Electrician and Director of Elec. and Chem. Laboratories; The Standard Underground Cable Co., Pittsburg, Pa.	Jan. 16, 1895
FISKE, HENRY G.	Electrician, 45 E. 22d St., New York City.	Nov. 12, 1889
FISKE, J. P. B.	Electrical Engineer, General Electric Co., Lynn, Mass.	June 17, 1890
FLACK, J. DAY	Supt. of Equipment, General Electric Co., Lamp Works, Harrison; residence, 80 Carlton St., East Orange, N. J.	Dec. 6, 1887
FLAGG, STANLEY G., JR.	Stanley G. Flagg & Co., 19th St., and Penna. Ave., Philadelphia, Pa.	April 18, 1893
FLANAGAN, THOMAS FRANCIS	Supt. and Electrician, Portsmouth Gas Light Co., Portsmouth, N. H	Jan. 17, 1894

Name.	Address.	Date of Election.
FLATHER, JOHN J.	Professor of Mechanical Engineering, Purdue University, Lafayette, Ind.	April 19, 1892
FLEGEL, GEO. C.	East Chicago, Ind.	Sept. 20, 1893
FLEMING, RICHARD	Electrician, Navy Yard, N. Y.; residence, Jamaica, N. Y.	Oct. 18, 1893
FLESCH, CHARLES	Electrical Engineer, Allgemeine Elektricitats-Gesellschaft, 22 Schiffbauerdamm, Berlin, N. W. Germany.	Sept. 27, 1892
FLINT, BERTRAM P.	Electrical and Mechanical Engineer, with Chas. H. Davis, 120 Broadway, New York City.	Jan. 17, 1894
FLOOD, J. F.	Sup't Steubenville Street Railway Co., Steubenville, O.	Mar. 18, 1890
FLOY, HENRY	Westinghouse Electric and Mfg. Co., Pittsburg, Pa.	May 17, 1892
FOOTE, ALLEN R.	Special Agent, Electrical Industries, U. S. Census, Takoma Park, D. C.	April 21, 1891
FOOTE, CHARLES W.	Consulting Electrical Engineer, Pomona, Cal.	Sept. 22, 1891
FOOTE, THOS. H.	Consulting Electrical Engineer, 215 West 125th St., New York City.	April 21, 1891
FORBES, FRANCIS	Lawyer, 32 Nassau St., New York City.	Sept. 16, 1890
FORBES, GEORGE	Electrical Engineer, 34 Great George St., London, Eng.	Feb. 21, 1894
FORD, WM. S.	Assistant to Chief Engineer, The American Bell Telephone Co., Room 73, 125 Milk St., Boston, Mass.	June 7, 1892
FRANCISCO, M. J.	President and General Manager, Rutland Electric Light Co., Rutland, Vt.	June 17, 1890
FRANTZEN, ARTHUR	Frantzen & Bennett, Electrical Contractors, 84 La Salle St., Chicago, Ill.	Feb. 21, 1894
FREEDMAN, WILLIAM H.	Tutor in Electrical Engineering, School of Mines, Columbia College; residence, 120 W. 125th St., New York City.	Mar. 18, 1890
FRENCH, PROF. THOMAS, JR.	*Ph.D.* Avondale, Cincinnati, O.	Sept. 20, 1893
FREY, CHARLES P.	Electrician, The E. S. Greeley & Co., 5 and 7 Dey St., New York City.	June 6, 1893
FROST, FRANCIS R.	58 Bluff St., Pittsburg, Pa.	Dec. 20, 1893
FRYE, HENRY W.	The *Electrical World*, 253 Broadway, New York City.	May 16, 1893
FULLER, FRANK G.	Salesman, with W. R. Brixey, 203 Broadway, New York City.	Oct. 19, 1894
FULLER, LEVI K.	Vice-President, Estey Organ Co., Brattleboro, Vt.	Mar. 5, 1889
GALLAHER, EDWARD B.	Electrical Engineer, 253 Broadway, room 910; residence, 1190 Madison, Ave., New York City.	Jan. 19, 1895

Name.	Address.	Date of Election.
GALLETLY, J. FRED.	Electrician, Swift & Co., Chicago, Ill.	Mar. 21, 1894
GARDANIER, GEORGE W.	Electrician, Western Union Telegraph Co., 195 Broadway, New York City.	April 18, 1893
GEORGE, JOHN C.	President, Raleigh Electric Street Railway Co., Marine Bank Building; residence, 33 South Gay St., Baltimore, Md.	April 18, 1894
GERRY, EDWARD M.	Western Electrical Instrument Co., 114 William St.; residence, 181 Washington St., Newark, N. J.	Feb. 21, 1894
GERRY, JAMES H.	Superintendent, The Self-Winding Clock Co., 163 Grand Ave., Brooklyn, N. Y.	April 18, 1894
GERRY, M. H., JR.	Engineer, St. Paul Office, General Electric Co., 3333 Cedar Ave., Minneapolis, Minn.	April 18, 1893
GERSON, LOUIS JAY	President and Electrical Engineer, The Gerson Electrical Co., 809 Sansom St., Philadelphia, Pa.	Sep. 19, 1894
GESSEAUME, CHARLES	Draughtsman, 78 Sheffield St., Newark, N. J.	Feb. 21, 1894
GILES, WALTER A.	Goubert Mfg. Co., 29 Cortlandt St., New York City.	Nov. 1, 1887
GILLILAND, E. T.	Pelham Manor, N. Y.	April 15, 1884
GLADING, FRANK W.	1 DeWitt Ave. Ithaca, N. Y.	May 15, 1894
GLADSTONE, JAMES WM.	Manager, Edison Mfg. Co., 110 East 23d St.; residence, West Orange, N. J.	April 18, 1894
GOLDMARK, CHAS. J.	Electrical Engineer, 49 Liberty St., and 473 Park Ave., New York City.	June 5, 1888
GOLDSBOROUGH, WINDER E.,	*M.E.*, Associate Professor of Electrical Engineering, Purdue University, Lafayette, Ind.	Mar. 21, 1893
GORTON, CHARLES	Civil Engineer, Belmont, N. Y.	Nov. 12, 1889
GORDON, REGINALD	Tutor in Physics, Columbia College, residence, 339 Lexington Ave., New York City.	Feb. 24, 1891
GOSSLER, PHILIP G.	Electrical Engineer, United Electric Light and Power Co., 108 Fulton St., New York City.	June 20, 1894
GRAHAM, GEORGE WALLACE	Secretary, Interior Telephone Co., 203 Broadway, New York; residence, 163 Hicks St., Brooklyn, N. Y.	Dec. 19, 1894
GRAY, W. N.	Electrical Engineer, 200 Neave Building, Cincinnati, O.	Oct. 1, 1889
GRIFFIN, CAPT. EUGENE	First Vice-President, General Electric Co., Schenectady, N. Y.; residence, 323 State St, Albany, N. Y.	Feb. 7, 1890
GROSS, S. ROSS	Electrician, Tennessee Coal, Iron and R.R. Co., Ensley, Ala.	May 17, 1892
GROWER, GEORGE G.	Electrician and Chemist, Ansonia Brass and Copper Co., Ansonia, Conn.	Mar. 18, 1890

Name.	Address.	Date of Election.
GUY, GEORGE HELI	Secretary, The New York Electrical Society, 534 Temple Court, New York City.	May 16, 1893
HADAWAY, W. S., Jr.	Electrician, Central Electric Heating Co., 26 Cortlandt St., New York City.	Nov. 21, 1894
HADLEY, ARTHUR L.	Assistant Electrician to Chief Electrician and Gen'l Supt., Fort Wayne Electric Corporation, 149 Griffith St., Fort Wayne, Ind.	Oct. 17, 1894
HADLEY, WARREN, B.	30 Cortlandt St., New York City.	June 26, 1891
HALL, EDWARD J.	Vice-President and General Manager, American Telephone and Telegraph Co., 18 Cortlandt St, New York City.	April 18, 1893
HALL, EDWIN H.	Assistant Professor of Physics, Harvard College, Gorham St., Cambridge, Mass.	Sept. 3, 1889
HALL, WILLIAM P.	President, The Hall Signal Co., Vice-President The Johnson Railroad Signal Co., 80 Broadway, New York City.	Sept. 16, 1890
HALSEY, WILLIAM B.	Electrician and Horologist, 246 Elton St., Brooklyn, N. Y.	Mar. 18, 1890
HAMMATT, CLARENCE S.	Supt., Jacksonville Electric Light Co., Jacksonville, Fla.	Sept. 20, 1893
HANCOCK, L. M.	With Western Electric Co., 227 South Clinton St., Chicago, Ill.	May 19, 1891
HANDLEY, ARTHUR	[Address unknown.]	Dec. 16, 1890
HARDING, H. McL.	253 Broadway, New York City.	May 24, 1887
HARRINGTON, WALTER E.	Electric Railway Engineer, 307 Market St., Camden, N. J.	Mar. 17, 1891
HARRIS, GEORGE H.	Superintendent, Electric Car Shops, Birmingham, Ala.	June 20, 1894
HARRISON, HAROLD	New York Representative, Slater Engine Co., Montclair, N. J.	Feb. 21, 1894
HART, FRANCIS R.	President and General Manager, Cartagena-Magdalena Railway Co., care of Old Colony Trust Co., 1 Court St., Boston, Mass.	April 21, 1891
HARTMAN, HERBERT T.	Works Engineer, Peterborough Factory, Canadian General Electric Co., Peterborough, Ont.	Mar. 21, 1893
HATZEL, J. C.	Electrical Engineer and Contractor, 114 Fifth Ave., New York City.	Sept. 3, 1889
HAVILAND, FOSTER L.	With Clark Electric Co., 192 Broadway; residence, 163 St. Nicholas Ave., New York City.	May 15, 1894
HEATH, HARRY E.	Chief Draughtsman, Eddy Electric Mfg. Co., Box 189, Windsor, Conn.	Mar. 21. 1893
HEALY, LOUIS W.	The Westinghouse Electric and Mfg. Co., Pittsburg, Pa.	June 26, 1891

Name.	Address.	Date of Election.
HEDENBERG, WM. L.	Firm of Hedenberg & Kinsey, Consulting and Constructing Engineers, 108 Fulton St.; residence, 83 Clinton Place, New York City.	Nov. 21, 1894
HENSHAW, FREDERICK V.	Electrical Engineer, The "C. & C." Electric Co., Garwood; P. O. Westfield, N. J.	Feb. 5, 1889
HEWITT, WILLIAM R.	Superintendent, Fire Alarm and Police Telegraph, 9 Brenham Place, San Francisco, Cal.	May 15, 1894
HEWLETT, EDWARD M.	Electrical Engineer, Railway Dept. General Electric Co., Schenectady, N. Y.	May 19, 1891
HIGGINS, EUGENE	Electrical Engineer, Springport, Mich.	April 19, 1892
HILL, GEORGE, *C.E.*	Consulting Engineer, 44 Broadway, New York City.	April 19, 1892
HIX, E. RANDOLPH	Hix, Hamilton & Co., Electrical Engineers and Contractors, 41 Wall St., New York City.	Feb. 21, 1894
HOBART, HENRY M.	Engineer, General Electric Co., Schenectady, N. Y.	April 18, 1894
HOCHHAUSEN, WILLIAM	Electrician, 74 Hanson Pl., Brooklyn, N. Y.	April 15, 1884
HOLBERTON, GEORGE C.	Electrical Engineer, General Electric Co., 15 First St., San Francisco, Cal.	May 15, 1894
HOLCOMB, EUGENE R.	[Address unknown.]	June 17, 1890
HOLLERITH, HERMAN	Hollerith Electric Tabulating System, 1054 31st St., Washington, D. C.	Sept. 19, 1894
HOLT, MARMADUKE BURRELL,	Mining and Electrical Engineer, The Colorado Smelting Co., Pueblo, Col.	April 15, 1890
HOOD, RALPH O.	Electrical Engineer, 15 Federal St., Boston, Mass.	April 18, 1894
HOWSON, HUBERT	Patent Lawyer, 38 Park Row, New York City.	June 8, 1887
HUBBARD, WILLIAM C.	Engineering Department, Marks-Ayer Electric Co., 73 Watt St., New York City; residence, 109 West 5th St., Plainfield, N. J.	April 18, 1894
HUBLEY, G. WILBUR	Electrical Engineer, Louisville Electric Light Co.; residence, Kenton Club, Louisville, Ky.	Sept. 19, 1894
HUBRECHT, DR. H. F. R.	Director, Nederlandsche Bell Telephone Co., Amsterdam, Holland.	Oct. 4, 1887
HUDSON, JOHN E.	President, The American Bell Telephone Co., 125 Milk St., Boston, Mass.	Dec. 20, 1893
HUMPHREYS, C. J. R.	Manager, Lawrence Gas Co., and Edison Electrical Ill. Co., Lawrence, Mass.	Sept. 6, 1887

Name.	Address.	Date of Election.
HUMPHREYS, PROF. WM. J.	Washington College, Chestertown, Md.	April 18, 1893
HUNT, ARTHUR L.	Electrician, Utica State Hospital, Utica, N. Y.	Sept. 19, 1894
HUTCHINSON, FREDERICK L.	Electrical Engineer with Westinghouse Electric and Mfg. Co., East Pittsburg, Pa.	June 20, 1894
IDELL, FRANK E.	Havemeyer Building, 26 Cortlandt St., New York City.	July 12, 1887
IHLDER, JOHN D.	Electrical Engineer, Otis Electric Co., Yonkers, N. Y.	Oct. 2, 1888
INGOLD, EUGENE	Consulting Engineer and Expert, 1669 Second Ave., Pittsburg, Pa.	April 18, 1894
INSULL, SAMUEL	President, Chicago Edison Co., 513 Rookery, Chicago, Ill.	Dec. 7, 1886
IWADARE, KUNIHIKO	Electrician, Osaka Electric Light Co., Osaka, Japan.	Sept. 20, 1893
IZARD, E. M.	Electrical Engineer, Room 1409, 315 Dearborn St., Chicago, Ill.	Mar. 5, 1889
JAEGER, CHARLES L.	Inventor, Maywood, N. J.	Dec. 20, 1893
JOHNSON, J. N.	Care Palmetto Milling and Com. Co., Columbia, S. C.	Sept. 20, 1893
JOHNSTON, W. J.	*The Electrical World*, 253 Broadway, New York City.	April 15, 1884
JONES, F. R.	Professor of Machine Design, University of Wisconsin, Madison, Wis.	May 20, 1890
JONES, ARTHUR W.	Care of H. H. Kingsbury, Sydney, N. S. W.	Oct. 17, 1894
JUDSON, WM. PIERSON	U. S. Civil Engineer, Oswego, N. Y.	June 8, 1887
KAMMEYER, CARL E.	Western Manager the *Electrical Engineer*, 1439 Monadnock Block, Chicago, Ill	Sept. 19, 1894
KEEFER, EDWIN S.	Supt. of Electric Light Construction, Western Electric Co., 22 Thames St., New York City; residence, Elizabeth, N. J.	April 18, 1894
KEILHOLTZ, P. O.	U. S. Electric Power and Light Co., Holliday and Centre Sts., Baltimore, Md.	Mar. 21, 1893
KELLER, CHAS. L.	Chicago Telephone Co.; Residence, 5910 East End Ave., Chicago, Ill.	Oct. 17, 1894
KELLER, E. E.	Vice-Prest. and General Manager, Westinghouse Machine Co., 224 Murtland Ave., Pittsburg, Pa.	Sept. 20, 1893
KELLER, EDWIN R., *M.E.*	Mechanical and Electrical Engineer, Falkenau Engineering Co., Ltd., 1210 Betz Building, 4823 Springfield Ave., Philadelphia, Pa.	Mar. 21, 1894
KELLOGG, JAMES W., *M.E.*	General Electric Co., Lighting Dept., Schenectady, N. Y.	June 26, 1891

Name.	Address.	Date of Election.
KENNELLY, A. E.	(*Manager.*) Electrician, Firm of Houston & Kennelly, 1105–1106 Betz Bldg., Philadelphia, Pa.	May 1, 1888
KIMBALL, DR. ALONZO S.	Professor of Physics, and Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass.	Sept. 3, 1889
KINNEY, HARRY A.	Storage Battery Mfg. Co., St. Louis, Mo.	Mar. 18, 1890
KIRKEGAARD, GEORG	Supt. Solar Arc Lamp Co., 351 Jay St., Brooklyn, N. Y.	Sept. 20, 1893
KIRKLAND, JOHN W.	Electrical Engineer, General Electric Co., Schenectady, N. Y.	Mar. 21, 1894
KNOX, FRANK H.	White-Crosby Co., 2116 N. Charles St., Baltimore, Md.	June 20, 1894
KNOX, JAMES MASON	Student in Electrical Engineering, Columbia College, School of Mines; Residence, 32 West 129th St., New York City.	Jan. 17, 1894
KREIDLER, W. A.	Editor and Publisher, *Western Electrician*, 6 Lakeside Building, Chicago, Ill.	Oct. 4, 1887
LAND, FRANK	Globe Hotel, Syracuse, N. Y.	Sept. 22, 1891
LANE, VANCE	Manager and Superintendent Construction, Nebraska Telephone Co., Omaha, Neb.	Dec. 19, 1894
LANPHEAR, BURTON S.	Fellow and Graduate Student in Electrical Engineering, Cornell University; residence, 106 Union Ave., Ithaca, N. Y.	Jan. 16, 1895
LANMAN, WILLIAM H.	Patent Dept., General Electric Co., 44 Broad St., New York City.	June 6, 1893
LARDNER, HENRY ACKLEY	Instructor in Electrical Engineering, State College, Penn.	Dec. 19, 1894
LARNED, SHERWOOD J.	Electrical Engineer, Chicago Telephone Co., 203 Washington St., Chicago, Ill.	Oct. 17, 1894
LA ROCHE, FRED. A.	President and Manager, La Roche Electric Works, American and Diamond Sts., Residence, 2235 N. 16th St., Philadelphia, Pa.	Sept. 19, 1893
LAWTON, W. C.	Roselle, N. J.	June 6, 1893
LEDOUX, A. R., *M. S., Ph.D.*,	9 Cliff St., New York City.	Dec. 7, 1886
LEE, JOHN C.	Chemist and Electrician, American Bell Telephone Co., Mountfort St., Longwood, Brookline, Mass.	Mar. 18, 1890
LENZ, CHARLES OTTO	Electrical Engineer, Room 510, Industrial Trust Bldg., Providence, R. I.	Mar. 15, 1892
LESLIE, EDWARD A.	Vice-President and Manager, Manhattan Electric Light Co., Ltd., New York City; residence, 343 Hancock St., Brooklyn, N. Y.	Jan. 16, 1895

Name.	Address.	Date of Election
LESTER, WILLIAM B.	Western Union Telegraph Co., 195 Broadway; residence, 346 Lenox Ave., New York City.	Jan. 16, 1895
LEVIS, MINFORD	Superintendent, and Electrical Engineer, Novelty Electric Co., 54 North 4th St., Philadelphia, Pa.	Feb. 21, 1893
LEVY, ARTHUR B.	Assistant Engineer, Arc Light Dept., General Electric Co., 810 Lexington Ave., New York City.	Jan. 20, 1891
LEWIS, HENRY FREDERICK WILLIAM,	Redlands, 48 Sydenham Road, Croydon, Surrey, England.	Mar. 5, 1889
LIEBIG, GUSTAV A., JR.	Electrical Testing Bureau, Johns Hopkins University, Baltimore, Md.	Mar. 6, 1888
LILLEY, L. G.	Electrical Inspector, Underwriters' Association of Cincinnati, Wyoming, O.	June 20, 1894
LIGHTHIPE, JAMES A.	District Engineer, General Electric Co., 15 First St., San Francisco, Cal.	Feb. 21, 1894
LINDNER, CHAS. T.	Martin & Lindner, Electrical Engineers, Luning Building, San Francisco, Cal., residence Berkeley, Cal.	Dec. 20, 1893
LLOYD, HERBERT	General Manager, Electrical Engineer and Chemist, The Electric Storage Battery Co., Drexel Bldg., Philadelphia, Pa.	June 20, 1894
LOOMIS, OSBORN P.	Electrical Engineer, Bound Brook, N. J.	Sept. 16, 1890
LOW, GEORGE P.	Consulting Electrical Engineer, Electrical Inspector, Pacific Insurance Union, 303 California St., San Francisco, Cal.	Jan. 17, 1893
LOZIER, ROBERT T. E.	Electrical Engineer, Warren & Lozier, 465 Greenwich St., New York City.	May 20, 1890
LUFKIN, HARVEY L.	Crocker-Wheeler Electric Co., 39 Cortlandt St., New York City.	June 17, 1890
LUNDELL, ROBERT	Electrical Engineer, Interior Conduit and Insulation Co., 44 Broad St., New York; residence, 47 Brevoort Pl., Brooklyn, N. Y.	Feb. 7, 1890
LUQUER, THATCHER, T. P.	Bedford, N. Y.	June 26, 1891
LYMAN, CHESTER WOLCOTT	Manager, Herkimer Paper Co., Herkimer, N. Y.	Sept. 19, 1894
LYMAN, JAMES [Life Member.]	Student in Electrical Engineering at Cornell University, 39 Eddy St., Ithaca, N. Y.; residence, Middlefield, Conn.	Sept. 19, 1894
MACFADDEN, CARL K.	Nutting Electric Mfg. Co., 128 So. Clinton St., Chicago, Ill.	Sept. 27, 1892
MACKIE, C. P.	Manager, Electric Selector and Signal Co., 45 Broadway, New York City.	Mar. 21, 1893
MACMULLAN, ROBERT HEATH,	Lafayette, Ind.	Sept. 22, 1891

Name.	Address.	Date of Election.
MACQUESTEN, W. D.	Electrical Engineer and Contractor, Room 25, 15 Cortlandt St., New York City.	April 15, 1890
MADDEN, OSCAR E.	41 and 43 Wall St., New York City.	April 15, 1884
MAGEE, LOUIS J.	Electrical Engineer, Director, der Union Elektricitats Gesellschaft, Corneliusstr 1., Berlin, W. Germany.	April 2, 1889
MAGENIS, JAMES P.	Editor, The *Adams Freeman*, Adams, Mass.	Sept. 27, 1892
MALCOLM, PHILIP S.	Electrical Engineer and Contractor, 131 Sixth St., Portland, Ore.	Mar. 18, 1890
MALIA, JAMES P.	Electrician, Armour & Co., 5314 Union Ave., Chicago, Ill.	June 20, 1894
MANN, FRANCIS P.	London, Eng.	June 6, 1893
MANSFIELD, GEO. W.	Electrical Engineer, Melrose Highlands, Mass.	June 2, 1885
MARTIN, A. J.	General Supt., West End Electric Co., 1308 North 29th St., Philadelphia, Pa.	Mar. 15, 1892
MARTIN, FRANK	Electrical Engineer, Madison Square Garden Company, New York City.	Oct. 21, 1890
MARTIN, J.	Electrician, 16 Oak St., Newark, N. J., Master Electrician, Equipment Dept., New York Navy Yard.	Oct. 21, 1890
MARTIN, T. COMMERFORD	(*Past-President.*) Editor, *The Electrical Engineer*, 203 Broadway, New York City.	April 15, 1884
MASON, JAMES H.	Electrical Expert, 10 Fifth Ave., Brooklyn, N. Y.	May 19, 1891
MATTHEWS, CHARLES P.	Instructor in Physics, Cornell University, 211 E. State St., Ithaca, N. Y.	May 16, 1893
MAURO, PHILIP	Counsellor at-Law in Patent Causes (Pollock & Mauro), 620 F. St., Washington, D. C.	Dec. 21, 1892
MAYRHOFER, JOS. CARL	Electrical Engineer, 165 W. 82d St., New York City.	June 20, 1894
MCBRIDE, JAMES	Superintendent, N. Y. & Boston Dye Wood Co., 146 Kent St., Brooklyn, N. Y.	Sept. 27, 1892
MCCARTHY, LAWRENCE A.	Western Union Telegraph Co., New York City, 1053 Bedford Ave., Brooklyn, N. Y.	Jan. 19, 1892
MCCLURG, W. A.	Manager, Electrical Dept., Plainfield Gas and Electric Light Co., 207 Madison Ave., Plainfield, N. J.	Dec. 20, 1893
MCCROSKY, JAMES W.	Electrical Engineer, Westinghouse Electric and Mfg. Co., Pittsburg, Pa.	Dec. 20, 1893
MCCROSSAN, J. A.	Manager and Electrician, Citizens' Telephone and Electric Co., Rat Portage, Ont.	Oct. 18, 1893

Name.	Address.	Date of Election.
McELROY, JAMES F.	Mechanical Supt., The Consolidated Car Heating Co., 131 Lake Ave., Albany, N. Y.	Nov. 15, 1892
McKAY, C. R.	Consulting Engineer, 140 South Main St., Salt Lake City, Utah.	Dec. 20, 1893
McKIBBIN, GEORGE N.	Reed & McKibbin, General Street Railway Contractors, 80 Broadway, New York City.	June 8, 1887
McKINSTRY, J. P.	General Manager, Cleveland Telephone Co., 316 Seneca St., Cleveland, O.	April 15, 1884
McKISSICK, A. F.	Professor of Electrical Engineering, The A. & M. College of Ala., Auburn, Ala.	Feb. 16, 1892
McRAE, AUSTIN LEE	Professor of Physics, University of Texas, Austin, Texas.	May 17, 1892
MEDINA, FRANK P.	Electrician, Pacific Postal Telegraph Co., 534 Market St., San Francisco, Cal.	Sept. 19, 1894
MERCER, ANDREW G.	Electrician, Waterloo Electric Co., Waterloo, N. Y.	Sept. 3, 1889
MEREDITH, WYNN	Electrical Engineer, Hasson & Hunt, 310 Pine St., San Francisco, Cal.	Jan. 17, 1894
MERRILL, E. A.	Electrical Engineer, Pierce & Miller Engineering Co., 42 Cortlandt St., New York City.	Sept. 20, 1893
MERRITT, ERNEST	Assistant Professor in Physics, Cornell University, Ithaca, N. Y.	Sept. 16, 1890
MEYER, JULIUS	Consulting Engineer, 44 Broad St., New York City.	Oct. 25, 1892
MILLER, JOSEPH A.	Civil and Consulting Engineer, 25 Butler Exchange, Providence, R. I.	Dec. 9, 1884
MILLER, WM. C., *M. S.*	Electrical Engineer, 3 South Hawk St., Albany, N. Y.	Oct. 21, 1890
MINER, WILLARD M.	Electrician and Inventor, 339 East Second St., Plainfield, N. J.	July 12, 1887
MITCHELL, JOHN MURRAY	Lawyer, Box 3712, 35 Wall St., New York City.	June 2, 1885
MITCHELL, SIDNEY Z.	Manager, Oregon, Washington and Idaho Agency, General Electric Co., Fleischner Building, Portland, Ore.	Nov. 12, 1889
MIX, EDGAR W.	Electrician, with Thomson-Houston International Electric Co., 27 Rue de Loudres, Paris, France.	Sept. 3, 1889
MONELL, JOSEPH T.	Consulting Electrical Engineer, 236 W 22d St., New York City.	Oct. 27, 1891
MOORE, JOHN J.	[Address unknown.]	Nov. 12, 1889
MORDEY, WM. MORRIS	Electrician, Brush Electrical Engineering Co., 34 Montserrat Road, Putney, London, Eng.	Sept. 23, 1891

Name.	Address.	Date of Election.
MOREHOUSE, H. H.	General Manager and Electrician, Alumbrado Electrico de Quezaltenango, Apartado, No. 44, Quezaltenango, Guatemala, C. A.	Feb. 21, 1894
MORRISON, J. FRANK	15 South St., Baltimore, Md.	April 15, 1884
MORSE, GEORGE H.	910 Wright Block, Minneapolis; residence, Excelsior, Minn.	May 15, 1894
MORSS, EVERETT	Vice-President, Simplex Electric Co., 303 Marlboro St., Boston, Mass	Sept. 22, 1891
MORTON, HENRY, *Ph.D.*	President of Stevens Institute of Technology, Hoboken, N. J.	May 24, 1887
MOSES, DR. OTTO A.	Electrician, 1037 Fifth Ave., New York City.	May 17, 1887
MOSSCROP, WM. A., *M.E*	Electrical Engineer, 29 Clifton Place, Brooklyn, N. Y.	May 7, 1889
MOTT, S. D.	Electrical Engineer and Inventor, Passaic, N. J.	Sept. 20, 1893
MOTTRAM, WILLIAM T. M.	Dallas, Tex.	Mar. 21, 1893
MUNNS, CHAS. K.	Electrician, Strowger Autom. Tel. Exchange; residence, 1002 W. Monroe St., Chicago, Ill.	Nov. 21, 1894
MUSTIN, HERBERT S.	Electrician, care of American Mfg. and Engineering Co., 143 Liberty St., New York City.	Dec. 20, 1893
MYERS, GEO. FRANCIS	Inventive Engineer, Penn Building, Pittsburg, Pa.	June 17, 1890
MYERS, L. E.	Secretary and Treasurer, Electrical Installation Co., 917 Monadnock Building, Chicago, Ill.	Sept. 19, 1894
NEILER, SAMUEL G.	1409 Manhattan Building, Chicago, Ill.	April 18, 1894
NEWELL, ARTHUR J.	Electrical Engineer, R T. Oakes & Co., 366 High St., Holyoke, Mass.	Mar. 18, 1890
NICHOLSON, WALTER W.	General Supt. Central N. Y. Telephone and Telegraph Co., 73 Howard Ave., Utica, N. Y.	May 15, 1894
NORTON, ELBERT F.	Chief Inspector, City Electrical Inspection, 15 City Hall, Chicago, Ill.	Dec. 20, 1893
NOXON, C. PER LEE	Contracting Electrical Engineer, 628 Mission St., San Francisco, Cal.	Oct. 17, 1894
NUNN, RICHARD J., *M.D.*	Physician, 119½ York St., Savannah, Ga.	July 12, 1887
NUTTING, SAMUEL E.	Electrician and Supt., Nutting Electric Mfg. Co., 241 South Scoville Ave., Oak Park, Ill.	Sept. 20, 1893
OCKERSHAUSEN, H. A.	Electrical Engineer, 65 Madison Ave., Jersey City, N. J.	Sept. 6, 1887
O'CONNELL, J. J.	Telephone Engineer, Chicago Telephone Co., Residence, 76 Eugene St., Chicago Ill.	Oct. 17, 1894
O'DEA, M	Electrician, University of Notre Dame, Notre Dame, Ind.	June 8, 1887

Name.	Address.	Date of Election
OLAN, THEODOR, J. W.	Civil and Electrical Engineer, 69 West 49th St., New York City.	May 16, 1893
OLIVETTI, CAMILLO	Ingegnere Industriale, Ivrea, Italy.	Oct. 17, 1894
OSBORNE, LOYALL ALLEN	President, Osborne Switch Co., 523 Prudential Building. Newark, N. J.	Oct. 18, 1893
OSTERBERG, MAX, *E.E.*	Associate Editor *Electric Power*, and Post Graduate Student of Mathematical Physics, Columbia College; residence, 232 East 62nd St., New York City,	Jan. 17, 1894
OTTEN, DR. JAN D.	Engineer, Union Elektricitats Gesellschaft, Kleinbeeren-strasse 21, Berlin, S. W. Germany.	Nov. 18, 1890
OUDIN, MAURICE	Electrical Engineer, General Electric Co., Schenectady, N. Y.	June 20, 1894
OWENS, R. B.	Professor of Electrical Engineering, University of Nebraska, Lincoln, Neb.	June 17, 1890
PAGE, A. D.	Assistant Manager, General Electric Co. Lamp Works, Harrison, N. J.	Jan. 19, 1892
PARCELLE, ALBERT L.	Electrician and Inventor, 157 Washington St., Boston, Mass.	Dec. 16, 1891
PARKER, HERSCHEL C.	Tutor in Physics, Columbia College, 21 Fort Green Pl., Brooklyn, N. Y.	April 19, 1892
PARMLY C. HOWARD, *S.M.*, *E.E.*	College of the City of New York, 17 Lexington Ave.; residence, 344 W. 29th St., New York City.	Feb. 21, 1893
PARSELL, HENRY V., JR.	31 E. 21st St., New York City.	Nov. 12, 1889
PAUL, CHAS. M.	Electrician, 172 Remsen St., Brooklyn, N. Y.	May 7, 1889
PECK, EDWARD F.	General Supt. Citizens Electric Illuminating Co., cor. Rockwell Pl. and DeKalb Ave., Brooklyn, N. Y.	May 20, 1890
PECK, SAMUEL C.	Electrician, Apartado 403, City of Mexico, Mexico.	Sept. 6, 1887
PEDERSEN, FREDERICK MALLING	Assistant Electrical Engineer, Crocker-Wheeler Electric Co., Ampere, E. Orange, N J.; residence, 327 W. 34th St., New York City.	Sept. 20, 1893
PEIRCE, WM. H.	Assistant Manager, Baltimore Smelting and Rolling Co., Keyser Bldg, German and Calvert Sts., Baltimore, Md.	Sept. 7, 1888
PERKINS, FRANK C.	Electrical Engineer and Contractor, 774 Prospect Ave., Buffalo, N. Y.	Oct. 21, 1890
PEROT, L. KNOWLES	General Manager, Eastern Engineering and Construction Co., 308 Walnut St., Philadelphia, Pa.	Mar. 15, 1892
PETTY, WALTER M.	Superintendent Fire Alarm Telegraph, Rutherford, N. J.	May 16, 1893
PFUND, RICHARD	With Western Union Telegraph Co., 195 Broadway, New York City.	April 18, 1893

Name.	Address.	Date of Election.
PHILBRICK, B. W.	Electrician, in charge of Electrical Plant. Hon. Levi P. Morton, Rhinecliff, N. Y.	May 15, 1894
PHILLIPS, EUGENE F.	Manufacturer Insulated Electric Wire, Providence, R. I.	July 13, 1889
PHILLIPS, LEO A.	Westinghouse Electric and Mfg. Co., East Pittsburg, Pa.	Mar. 21, 1894
PLUMB, CHARLES	Proprietor and Electrician, The Chas. Plumb Electrical Works, 89 Erie St., Buffalo, N. Y.	June 20, 1894
POOLE, CECIL P.	Contracting Electrical Engineer, 108 Eighth St., Lynchburg, Va.	Jan. 3, 1888
POPE, RALPH W.	Secretary to the American Institute of Electrical Engineers, 26 Cortlandt St., (Telephone, 2199 Cortlandt), New York City; residence, 570 Cherry St., Elizabeth, N. J.	June 2, 1885
POTTS, CHAS. EDWIN, *B. S., E. E.*	Engineer, 1356 Dean St., Brooklyn, N. Y.	Feb. 21, 1894
POTTER, HENRY NOEL	Electrician, Steglitzer Strasse, 10 parterre, Berlin W., Germany.	Sept. 19, 1894
POWELL, WILLIAM H.	Electrical Engineering Dep't, Lehigh University, South Bethlehem, Pa.	June 17, 1890
PRATT, CHARLES A.	Electrical Engineer. The Independent Electric Co., 30th St. and Stewart Ave,, Chicago, Ill.	Dec. 19, 1894
PRICE, CHAS. W.	Editor the *Electrical Review*, 13 Park Row, New York City; residence, 223 Garfield Place, Brooklyn, N. Y.	Sept 19, 1894
PRIVAT, LOUIS	Electrician, Cicero Water. Gas and Electric Light Co., Oak Park, Ill.	Dec. 19, 1894
PROCTOR, THOS. L.	General Manager, Riker Electric Motor Co., Newtown, L. I., N. Y.	April 18, 1894
PUFFER, WM. L.	Assistant Professor of Electrical Engineering, Mass. Institute of Technology, Boston, Mass.	Dec. 20, 1893
PUPIN, DR. MICHAEL I.	(*Manager.*) Adjunct Professor in Mechanics, Columbia College, New York City, 46 W. 72d St., New York.	Mar. 18, 1890
RANDALL, JOHN E.	Columbia Incandescent Lamp Co., 1912 Olive St., St. Louis, Mo.	May 7, 1889
RANDOLPH, L. S.	Professor of Mechanical Engineering, Blacksburg, Va.	Feb. 21, 1893
RAY, WILLIAM D.	Superintendent Everett Railway and Electric Co., Everett, Washington.	Sept. 27, 1892
READ, ROBERT H.	Firm of Pope, Read & Rogers, 39 Cortlandt St., New York City.	Jan. 19, 1892
REBER, SAMUEL	Lieut. Signal Corps, U. S. Army, Fort Riley, Kan.	Sept. 20, 1893
REED, CHAS. J.	Electrician, 609 Norris St., Philadelphia, Pa.	Mar. 5. 1889

Name.	Address.	Date of Election.
REED, HARRY D.	Electrician, Bishop Gutta Percha Co., 420 East 25th St., New York City; residence, 88 North 9th St., Newark, N. J.	Sept. 19, 1894
REED, HENRY A.	Secretary and Manager, Bishop Gutta-Percha Co., 422 East 25th St., New York City; residence, 88 North 9th St., Newark, N. J.	June 4, 1889
REID, THORBURN	Electrical Engineer, General Electric Co., Schenectady, N. Y.	Oct. 21, 1890
REILLY, JOHN C.	General Supt., N. Y. & N. J. Tel. Co., 16 Smith St., Brooklyn, N. Y.	April 15, 1884
REINMANN, A. L.	[Address unknown.]	June 8, 1887
RENNARD, JOHN CLIFFORD, *A. B. E. E.*	Assistant to Electrical Engineer, Met. Telephone and Tel. Co.; residence, 302 W. 73d St., New York City.	Jan. 16, 1895
REQUIER, A. MARCEL	Electrical Engineer, Westinghouse Electric and Manufacturing Co., Pittsburg, Pa.	Dec. 20, 1893
RHODES, S. ARTHUR	Electrician, Chief Testing Department, Chicago Telephone Co, Chicago, Ill.; residence, 429 North Pine Ave., Austin, Ill.	Oct. 17, 1894
RICHARDSON, ALBERT E.	Lecturer in Science, 21 Knight's Park, Kingston-on-Thames, England.	Feb. 21, 1894
RICHARDSON, ROBERT E.	Electrical Engineer, Pierce & Richardson, 1409 Manhattan Building; residence, 3827 Forest Ave, Chicago, Ill.	Sept. 19, 1894
RICKER, CHARLES W.	Expert Electrical Engineer, 109 White Bldg., Buffalo, N. Y.	May 15, 1894
RIDLEY, A. E. BROOKE	Agent, Electrical Engineer, Siemens & Halske Electric Co., 508 California St., San Francisco, Cal.	Nov. 21, 1894
RIKER, ANDREW L. [Life Member.]	Electrical Engineer, 737 Madison Ave., New York City.	Nov. 1, 1887
RITTENHOUSE, CHAS. T.	Post-Graduate Student, Columbia College, 247 W. 138th St., New York City.	Feb. 21, 1894
ROBB, RUSSELL	With Stone & Webster, 4 Post Office Sq., Boston, Mass.	Oct. 18, 1893
ROBERSON, OLIVER R.	Electrician, Western Union Telegraph Co., 195 Broadway, P O. Box 856, New York City.	Dec. 20, 1893
ROBERTS, WM. H.	15 Harrison St., Cincinnati, O.	Sept. 19, 1894
ROBINSON, ALMON	Draughtsman, Expert in Methods of Gearing, P. O. Box 943, Lewiston, Me.	Sept. 6, 1887
ROBINSON, FRANCIS G.	Foreman, Bushwick and Union Ave. Depots, Brooklyn Heights R. R. Co.; residence, 156 Macon St., Brooklyn, N. Y.	Nov. 21, 1894

Name.	Address.	Date of Election.
RODMAN, SAMUEL, JR.	(Late 1st Lieut., 2nd U. S. Artillery), Electrician and Expert in High Explosives. Room 106, Pullman, Bldg., Chicago, Ill.	Sept. 16, 1890
ROEBLING, FERDINAND W.	Manufacturer of Electrical Wires and Cables, Trenton, N. J.	June 8, 1887
ROESSLER, S. W.	Captain, Corps of Engineers U. S. A., 99 Madison St., Memphis, Tenn.	Dec. 3, 1889
ROGERS, EDWARD H.	Patent Lawyer, Firm of Pope, Read & Rogers, New Haven, Conn.	Sept. 22, 1891
ROLLER, JOHN E.	Lieut. U. S. N., in charge of Inspection and Installation, U. S. Navy Yard, New York: residence, 515 Clinton Ave., Brooklyn, N. Y.	Sept. 19, 1894
ROPER, DENNEY W.	Expert Department, General Electric Co., 302 Union St., Schenectady, N. Y.	June 6, 1893
ROSEBRUGH, THOMAS REEVE	Lecturer in Electrical Engineering, School of Practical Science, Toronto, Ont.	June 26, 1891
ROSENBAUM, WM. A.	Electrical Expert and Patent Solicitor, 177 Times Building, New York City.	Jan. 3, 1889
ROSENBERG, E. M.	Engineers' Department, Broadway and 7th Ave. Railroad; residence, 784 Lexington Ave., New York City.	Oct. 21, 1890
ROWLAND, ARTHUR JOHN	Professor of Electrical Engineering, Drexel Institute: residence, 4007 Powelton Ave., Philadelphia, Pa.	Sept. 19, 1894
ROWLAND, HENRY A.	Professor of Physics, Johns Hopkins University, Baltimore, Md.	Mar. 21, 1894
ROYCE, FRED W.	Electrician and Patent Solicitor, 1410 Pennsylvania Ave., Washington, D. C.	April 15, 1884
RUTHERFORD, W. M.	Chief Engineer, Canadian General Electric Co., 63 Front St., W. Toronto, Can.	Sept. 22, 1891
RYAN, HARRIS, J.	(*Manager.*) Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.	Oct. 4, 1887
SACHS, JOSEPH	Devising and Consulting Electrical Engineer, 32 Nassau St., New York City.	Mar. 15, 1892
SACKETT, WARD M.	Assistant Chief Draughtsman, Chicago Telephone Co., residence 3249 Groveland Ave., Chicago, Ill.	Oct. 17, 1894
SAGE, HENRY JUDSON	Engineer, Lighting and Power Dept., Western Electric Co., 227 So. Clinton St.; residence, 4467 Oakenwald Ave, Chicago, Ill.	Dec. 20, 1893
SAHULKA, DR. JOHANN	Docent of Electrotechnics, Technische Hochschule, Vienna, Austria	Dec. 20, 1893
SANBORN, FRANCIS N.	Assistant Superintendent, Susquehanna Coal Co., Nanticoke, Pa.	Nov. 24, 1891

Name.	Address.	Date of Election.
SANDERSON, EDWIN N.	New England Manager, Westinghouse Electric and Mfg. Co., 620 Atlantic Ave., Boston, Mass.; residence, Newton Centre, Mass.	Oct. 17, 1894
SAXELBY, FREDERICK	Electrical Engineer, 288 Summer Ave., Newark, N. J.	June 5, 1888
SCHEFFLER, FRED. A.	Stirling Boiler Co., 126 Liberty St., New York City; residence, Passaic, N. J.	May 16, 1893
SCHEIBLE, ALBERT	Secretary and Assistant, with George Cutter, 486 North Park Ave., Chicago, Ill.	June 20, 1894
SCHLOSSER, FRED. G.	Superintendent of Electric Dept., Laclede Gas Light Co., 1038 Leffingweil Ave., St. Louis, Mo.	Sept. 22, 1891
SCHMID, ALBERT	Superintendent, Westinghouse Electric and Mfg. Co., Pittsburg, Pa.	Oct. 21, 1890
SCHOEN, ALLEN MCGEE	Electrician, South Eastern Tariff Association, Atlanta, Ga.	Sept. 20, 1889
SCHREITER, HEINR, *C. E.*	Editor, "*Der Techniker*," 11 Chambers St, New York City.	Jan. 17, 1893
SEARING, LEWIS	Shepard & Searing, Mechanical and Electrical Engineers, 513 and 514 Mining Exchange, Denver, Col.	April 3, 1888
SEARLES, A. L.	Engineering Dept., The Marks-Ayer Electric Co., 73 Watt St, New York City and 291 7th Ave., Brooklyn, N. Y.	April 18, 1894
SEE, A. B.	A. B. See Manufacturing Co., 116 Front St.; residence, 107 East 19th St, (Flatbush), Brooklyn, N. Y.	Jan. 17, 1893
SEELY, J. A.	Electrical Engineer and Contractor, 121 Liberty St., New York City.	April 15, 1884
SEITZINGER, HARRY M.	Consulting and Constructing Engineer, 6 Northampton St., Wilkesbarre, Pa.	Sept. 20, 1893
SELDEN, R. L., JR.	Deep River, Conn.	Jan. 17, 1893
SERRELL, LEMUEL WM.	Mechanical and Electrical Engineer, 253 Broadway, New York City.	Nov. 1, 1887
SEVER, GEORGE F.	Instructor in Electrical Engineering, Columbia College, 34 West 32nd St., New York City.	Jan. 17, 1894
SERVA, A. A.	With Fort Wayne Electric Corporation, 29 West Jefferson St., Fort Wayne, Ind	Dec. 20, 1893
SHAIN, CHARLES D.	136 Liberty St., New York City.	June 7, 1892
SHARP, CLAYTON H.	Instructor, Department of Physics, Cornell University, 122 University Ave., Ithaca N. Y.	May 15, 1894
SHAW, EDWIN C.	Manager, Akron General Electric Co., Akron, O.	May 17, 1892
SHEBLE, FRANKLIN	Sheble & Parton, Ltd., 1022 Arch St, Philadelphia, Pa.	Oct. 21, 1890

Name.	Address.	Date of Election.
SHEDD, JOHN C.	Professor of Physics and Applied Electricity, Marietta College; residence, 512 Fourth St., Marietta, Ohio.	Dec. 19, 1894
SHEEHY, ROBERT J.	Engineer and Inventor, 570 Park Ave., New York City.	April 21, 1891
SHEPARDSON, GEORGE D.	Professor of Electrical Engineering, University of Minnesota, Minneapolis, Minn.	April 21, 1891
SHIELDS. W. J.	Shields & Wood, 829 Arch St., Philadelphia, Pa.	Sept. 19, 1894
SHRADER, WILLIAM	Professor of Electrical Engineering, University of Missouri, Columbia, Mo.	Sept. 20, 1893
SINCLAIR, H. A.	Electrical Engineer, The Tucker Electric Co., 950 Bedford Ave., Brooklyn, N. Y.	June 17, 1890
SISE, CHARLES F.	President, Bell Telephone Co., of Canada, P. O. Box 1918, Montreal, Canada.	June 8, 1887
SLADE, ARTHUR J., *Ph.D.*	Engineer, with George Hill, 44 Broadway; residence, 62 East 66th St., New York City.	Sept. 19, 1894
SLATER, FREDERICK R.	Designing Department, Otis Bros. & Co., 153 Warburton Ave., Yonkers, N. Y.	Oct. 17, 1894
SMITH, CHARLES HENRY	Box 346, Rome, Ga.	Jan. 17, 1894
SMITH, FRANK E.	Chief Electrician, Edison Light and Power Co., 229 Stevenson St., San Francisco, Cal.	Sept 19, 1894
SMITH, FREDERICK H.	Civil Engineer, 216 Equitable Bldg., Baltimore. Md.	Nov. 12, 1889
SMITH, HAROLD BABBITT	Professor of Electrical Engineering, Purdue University, 164 Columbia St., Lafayette, Ind.	Nov. 24, 1891
SMITH, J. BRODIE	Supt. and Electrician. Manchester Electric Light Co., 142 Merrimack St., Manchester, N. H.	Mar. 21, 1894
SMITH, J. ELLIOT	Superintendent Fire Alarm Telegraph, 122 W. 73d St., New York City.	April 15, 1884
SMITH, OBERLIN	President and Mechanical Engineer, Ferracute Machine Co., Lochwold, Bridgeton, N. J.	May 19, 1891
SMITH, T. JARRARD	Manager Electrical Dept., The E. S. Greeley & Co., 7 Dey St., New York City.	April 19, 1892
SOUZA, CARLOS MONTEIRO e	[Address unknown.]	Sept. 6, 1887
SPENCER, THEODORE	With Bell Telephone Co., 406 Market St., Philadelphia, Pa.	Mar. 21, 1893
SPICER, CHAS. W.	1054 31st St., Washington. D. C.	Nov. 12, 1889
SPIKE, CLARENCE J.	Halifax, N. S.	Mar. 18, 1890

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SPRAGUE, FRANK J.	(*Past-President.*) 182 West End Ave., Vice-Prest. Sprague Electric Elevator Co.. Firm of Sprague, Duncan & Hutchinson, Postal Telegraph Bldg., 253 Broadway, New York City	May 24, 1887
SPROUT, SIDNEY S.	Electrical Engineer, 303 California St., San Francisco, Cal.	Jan. 17, 1894
SPRUSON, WILFRED J.	Member of the firm of Hepburn & Spruson, Consulting Engineers and Electricians, 169 King St , Sydney, Australia.	Dec. 16, 1890
SQUIER, GEORGE O., *Ph.D.*	1st Lieut., 3d Artillery, Fortress Monroe, Va.	May 19, 1891
STADELMAN, WM. A.	[Address unknown.]	Feb. 7, 1890
STAHL, TH.	Creusot Works, Creusot, France.	Nov. 15, 1892
STANLEY, WILLIAM	Electrician, Pittsfield, Mass.	Dec. 6, 1887
STEARNS, JOEL W., JR.	Treasurer, Mountain Electric Co., Box 1545, Denver, Col.	June 20, 1894
STEPHENS, GEORGE	General Supt., Canadian General Electric Co., Ltd., Peterboro, Ont.	June 20, 1894
STEVENS, J. FRANKLIN	Secretary and Treasurer, La Roche Electric Works, American and Diamond Sts.; residence, 1419 Walnut St., Philadelphia, Pa.	Sept. 19, 1894
STINE, PROF. WILBUR M.	Director Electrical Dept., Armour Institute, Chicago, Ill.	May 15, 1894
STOCKBRIDGE, GEO. H.	Patent Attorney, Room 114, 39 Cortlandt St., New York City.	May 24, 1887
STOCKLY, GEO. W.	32 Liberty St , New York City; residence, Lakewood, N. J.	April 15, 1884
STONE, CHARLES A.	With Firm of Stone & Webster, 4 P. O. Sq., Boston, Mass.	May 19, 1891
STORRS, PROF. H. A.	Professor of Electrical Engineering, University of Vt., Burlington, Vt.	Mar. 21, 1893
STRATTON, MILTON G.	Electrician, U. S. Electric Light Co., 213 14th St., N. W., Washington, D. C.	Sept. 20. 1893
STRAUSS, HERMAN A.	Electrical Engineer, Westinghouse Electric and Mfg. Co., East Pittsburg, Pa.	Oct. 17, 1894
STRONG, FREDERICK G.	Box 959, Hartford, Conn.	Oct. 27, 1891
STUMP, CLARENCE E.	General Manager, *Street Railway Gazette*, 26 Cortlandt St., New York City.	May 17, 1887
STURTEVANT, CHARLES L.	Patent Attorney, Atlantic Building, Washington. D. C.	Dec. 20, 1893
SUMMERS, LELAND L.	Electrical Engineer, 436 The Rookery, Chicago, Ill.	Feb. 16, 1892
SVENTORZETZKY, CAPT. LOUDOMIR	Military Engineering Academy, St. Petersburg, Russia.	Sept. 20, 1893

Name.	Address.	Date of Election.
SWEET, HENRY N.	Chief of Patent Bureau, Thomson Electric Welding Co., 4 Spruce St, Boston, Mass.	May 20, 1890
SYKES, HENRY H.	Assistant Electrician, American Telephone and Telegraph Co., 75 Hicks St., Brooklyn, N. Y.	Oct. 18, 1893
TABER, ROBERT B.	Gas Engineer, Special Agent General Electric Co., 620 Atlantic Ave., Boston, Mass.	Sept. 16, 1890
TAIT, FRANK M.	Superintendent, Catasauqua Electric Light and Power Co., 731 3d St., Catasauqua, Pa.	Sept. 19, 1894
TAPLEY, WALTER H.	Electrician in Government Printing Office, care of Public Printer, Washington, D. C.	Oct. 25, 1892
TEMPLE, WILLIAM CHASE	Mechanical and Electrical Engineer, Lewis Block, P. O. Box 800, Pittsburg, Pa.	May 3, 1887
TESLA, NIKOLA	Electrical Engineer and Inventor, 35 So. 5th Ave., New York City.	June 5, 1888
THOMPSON, WILLIAM GEO.	MacNEILL Resident Engineer, Sault Ste. Marie Canal, St. Catharines, Ont.	July 12, 1887
TOBEY, WILLIAM BOARDMAN	General Manager, S. K. C. Specialty Co., Pittsfield, Mass.	Sept. 16, 1890
TOERRING, C. J., JR.	Electrical Engineer, Marks-Ayer Electric Co., 73 Watt St.; residence, 337 West 59th St., New York City.	April 18, 1894
TOWER, GEORGE A.	Electrical Engineer, The Sherwood Land Co., and The Jefferson Hotel Co., 109 S. First St., Richmond, Va.	May 15, 1894
TOWNSEND, HENRY C.	Attorney and Expert in Electrical Cases, 5 Beekman St., New York City.	July 10, 1888
TREADWELL, AUGUSTUS, JR.	Private Assistant, Polytechnic Institute, 488 3d St., Brooklyn, N. Y.	Feb. 21, 1894
TROTT, A. H. HARDY [Life Member.]	Electrical Expert, with General Electric Co., Lynn, Mass.	Jan. 20, 1891
TUTTLE, GEORGE W.	Storekeeper, Sawyer-Man Electric Co., 510 W. 23d St., New York City.	Mar. 17, 1891
VAIL, THEO. N.	18 Cortlandt St., New York City.	April 15, 1884
VAN BRUNT, WALTER	Manager, Duluth Telephone Co., Duluth, Minn.	Sept. 6, 1887
VAN BUREN, GURDON C.	Electrician and Electrical Contractor, 84 Clinton Ave., Albany, N. Y.	Oct. 25, 1892
VANCE, A. ST. CLAIR	[Address unknown.]	April 2, 1889
VANDEGRIFT, JAMES A.	Westinghouse Electric and Mfg. Co., Robinson St., Allegheny City, Pa.	Nov. 24, 1891
VANDERSLICE, G. HAMILTON	Westinghouse Electric and Mfg. Co., P. O. Box 911, Pittsburg, Pa.	Dec. 19, 1894
VAN VLECK, FRANK	President, Van Vleck Tramway Co., Wells Fargo Bldg., Los Angeles, Cal.	Nov. 16, 1886

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VAN WYCK, PHILIP V. R., JR.	981 Madison Ave., New York City.	April 21, 1891
VARLEY, RICHARD, JR.	General Manager, Varley Duplex Magnet Co., 62 Cortlandt St., New York City.	Mar. 18, 1890
VARLEY, THOMAS W.	Electrician. The Okonite Co., Ltd.; residence, 250 Bloomfield Ave., Passaic, N. J.	Sept. 19, 1894
VARNEY, WILLIAM WESLEY	Attorney at Law, Electrical Expert, 118 East Lexington St.; residence, 1001 Harlem Ave., Baltimore, Md.	Nov. 21, 1894
VERLEY, HORACE S. L.	With Dr. Wm. E. Geyer, as Laboratory Assistant, Stevens Institute, Hoboken, N. J.	May 17, 1892
VOIT, DR. ERNST	Professor of Electricity, Technical University. Schwanthalerstrasse, Munchen, Germany.	Mar. 21, 1894
WACKER, GEORGE G.	1340 Vanderbilt Ave., New York City.	Sept. 6, 1887
WALLACE, GEO. S.	Telegraph Office Manager, Chesapeake & Ohio Ry. Co., Box 214, Huntington, W. Va.	Oct. 25, 1892
WALLACE, WILLIAM	(*Vice-President.*) Wire Manufacturer, Ansonia, Conn.	April 15, 1884
WALTER, HENRY E.	3 Princes Mansions, Victoria St., London, Eng.	April 2, 1889
WARDELL, GEORGE P.	103 East Tenth St., New York City.	Nov. 12, 1889
WARDLAW, GEORGE A.	412 East Willow St., Syracuse, N. Y.	Jan. 17, 1894
WARING, RICHARD S.	Standard Underground Cable Co., 61 Westinghouse Bldg., Pittsburg, Pa.	April 15, 1884
WARING, JOHN	Waring Electric Co., Ovid, N. Y.	Dec. 16, 1890
WARNER, CHAS. H.	Consulting Electrical Engineer, 50 Broadway, New York City.	Dec. 20, 1893
WASON, CHAS. W.	Electrical Engineer and Purchasing Agent, Cleveland Electric R. R. Co., 1762 Euclid Ave., Cleveland, O.	May 19, 1891
WASON, LEONARD C.	Vice-Prest., The Aberthaw Construction Co., 12 Pearl St., Boston; residence, 199 Harvard St., Brookline, Mass.	Dec. 20, 1893
WATERHOUSE FRANK G.	Room 6, 302 Asylum St., Hartford, Conn.	Sept. 6, 1887
WATERS, EDWARD G.	Electrical Engineer, Pennsylvania General Electric Co., 425 Wood St., Pittsburg, Pa.	Mar. 18, 1890
WATSON, ROBERT	Patent Attorney, 931 F. St., N. W., Washington, D. C.	Oct. 21, 1890
WATTS, H. FRANKLIN	Electrical Engineer and Contractor, Norristown, Pa.	May 20, 1890
WEAVER, NORMAN R.	Box 87, Selma, Ala.	Oct. 25, 1892
WEBSTER, DR. ARTHUR G.	Assistant Professor of Physics, Clark University, 936 Main St., Worcester, Mass.	Jan. 19, 1892

Name.	Address.	Date of Election.
WEBSTER, EDWIN S.	Firm of Stone & Webster, 4 P. O. Sq., Boston, Mass.	April 21, 1891
WENDLE, GEORGE E.	2433 North 7th St., Philadelphia, Pa.	Feb. 21, 1894
WEST, JULIUS HENRIK	Engineer, Handjery St., 58 Friedenau, Berlin, Germany.	Sept. 20, 1893
WELLES, FRANCIS R.	Manufacturer, 46 Avenue de Breteuil, Paris, France.	Sept. 6, 1887
WHARTON, HUGH M.	Electrical Engineer, Westinghouse Electric and Mfg. Co , Room 102, 800 Broad St., Newark, N. J.	May 15, 1894
WHITE, H. C.	Manager, Phœnix Iron Works Co., 15 Cortlandt St., New York City.	April 15, 1884
WHITE, J. G.	J. G. White & Co., Electrical Engineers and Contractors, 29 Broadway, New York City.	April 2, 1889
WHITE, WILL F.	Electrical Engineer, Vice-President, New Omaha T.-H. Electric Light Co., 309 So. 13th St., Omaha, Neb.	Feb. 7, 1890
WHITE-FRASER, GEO.	Care of John Stark & Co., 28 Toronto St., Toronto, Ont.	Sept. 22, 1891
WHITMORE, W. G.	Electrical Engineer, General Electric Co., Edison Building, Box 3067, New York City.	Mar. 18, 1890
WHITNEY, HENRY M. [Life Member.]	81 Milk St., Boston, Mass.	July 12, 1887
WHITTEMORE, CHARLES F.	Livgro Lamp Co., Harrison, N. J.	Sept. 20, 1893
WIGHTMAN, MERLE J.	Library Building, Scranton, Pa.	Mar. 5, 1889
WILEY, WALTER S.	Supt. South Omaha Electric Light, Heat and Power Co., South Omaha, Neb.	April 18, 1894
WILEY, WM. H.	Scientific Expert, 53 E. 10th St., New York City.	Feb. 7, 1888
WILLIAMS, ARTHUR S.	[Address unknown.]	Nov. 24, 1891
WILLIAMS, CHARLES JR.	Electrician, 100 Sudbury St., Boston, Mass.	April 15, 1884
WILLIAMSON, G. DEWITT	Dobbs Ferry, N. Y.	April 18, 1893
WINAND, PAUL A. N.	Engineer and Supt., Schleicher, Schumm & Co., 3200 Arch St., Philadelphia, Pa.	June 20, 1894
WINCHESTER, SAMUEL B.	9 Laurel St., Holyoke, Mass.	May 15, 1894
WINSLOW, I. E.	British Thomson-Houston, Ltd., 38 Parliament St., Westminster, London, Eng.	Nov. 12, 1889
WINTRINGHAM, J. P.	Theorist, 36 Pine St , New York City, and 153 Henry St., Brooklyn, N.Y.	May 7, 1889
WIRT, HERBERT C.	Engineer, Supply Department, General Electric Co., Schenectady, N. Y.	June 26, 1891
WOOD, E. J.	Consulting Engineer and Contractor, 243 Broadway, New York City.	July 12, 1887

Name.	Address.	Date of Election.
WOODWARD, FRANCKE L.	Undergraduate in Electrical Engineering, Harvard University, 22 Perkins Hall, Cambridge, Mass.	June 26, 1891
WOOLF, ALBERT E.	Electrician and Inventor, Woolf Electric Disinfecting Co. of N. Y., 66 Broad St.; residence. 864 Lexington Ave., New York City.	Sept. 16, 1890
WORSWICK, A. E.	Electrical Engineer, Mutual Light and Power Co , 26 Commerce St , Montgomery, Ala.	Sept. 20, 1893
WRAY, J. GLEN	Cable Tester, Chicago Telephone Co., 162 Centre St., Chicago, Ill.	Sept 20, 1893
WRIGHT, JOHN D.	[Address unknown.]	Oct. 21, 1890
YARNALL, V. H.	Superintendent of Construction, White-Crosby Co., 29 Broadway, New York City.	May 16, 1893
ZALINSKI, EDMUND L.	Captain of Artillery, U. S. A., (retired), The Century, 7 West 43d St., New York City.	May 17, 1887
ZIMMERMAN, LAURENCE J.	Electrical Engineer and Inventor, 57 Pennsylvania Ave., Brooklyn, N. Y.	Mar. 21, 1893

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Gutmann, L., Care *St. Railway Rev.*
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Cross, Prof. Chas. R., Mass. Institute of Technology.
Cushing, H. C., 55 Kilby St.
Davenport, Geo. W., 61 Ames Bldg.
Doolittle, Thos. B., 125 Milk St.
Eustis, Herbert H., 61 Hampshire St.
Farnham, I. H., 125 Milk Street.
Ford, Wm. S., Room 73, 125 Milk St.
Hart, Francis R., 1 Court St.
Haskins, Caryl D., 620 Atlantic Ave.
Hayes, Hammond V., 42 Farnsworth St.
Herrick, Charles H., 196 Summer St.
Hood, Ralph O., 15 Federal St.
Hudson, John E., 125 Milk St.
Lockwood, Thomas D., 125 Milk St.
Morss, Everett, 303 Marlboro St.
Paine, F. B. H., 620 Atlantic Ave.
Paine, Sidney B., 180 Summer St.
Parcelle, Albert L., 157 Washington St.
Puffer, Wm. L., Mass. Inst. of Technology.
Robb, Russell, 4 P. O. Square.
Sanderson, E. N., 620 Atlantic Ave.
Stone, Charles A., 4 P. O. Square.

Boston.—Continued.

Sweet, Henry N., 4 Spruce St.
Taber, Robert B., 620 Atlantic Ave.
Webster, Edwin S., 4 P. O. Square.
Whitney, Henry M., 81 Milk St.
Williams, Chas. Jr., 100 Sudbury St.
40

Brookline.

Bliss, D. M., 1 Davis Ct., Washington St.
Lee, J. C., Mountfort St. Longwood.
Wason, L. C., 199 Harvard St.
3

Cambridge.

Adams, C. A. Jr., 13 Farrar St.
Hall, Prof. Edwin H., Gorham St.
Woodward, F. L., 22 Perkins Hall.
3

Fall River.

Beattie, John, Jr.
1

Holyoke.

Newell, Arthur J., 366 High St.
Winchester, S. B., 9 Laurel St.
2

Jamaica Plain

Brophy, William, 17 Egleston St.,
1

Lawrence.

Humphreys, C. J. R.
1

Lynn.

Ekstrom, Axel, 92 Hamilton Ave.
Everest, A. R., Thomson Electric Welding Co.
Fish, Walter C., Gen. Elec. Co.
Fiske, J. P. B., General Electric Co.
Lemp, H. Jr., Thomson Electric Welding Co.
Thomson, Prof. Elihu, General Electric Co.
Trott, A. H. H., General Electric Co.
7

Marlboro.

Bottomley, Harry.
de Khotinsky, Capt. Achilles.
2

Melrose Highlands.

Mansfield, Geo. W.
1

Newton Centre.

Stearns, Chas. K.
1

Pittsfield.

Chesney, C. C., Stanley Laboratory.
Stanley, William,
Tobey, W. B.,
Cor. Dawes Ave. & High St.
3

Springfield.

Anderson, H. S.. United E. L. Co.
Criggal, J. E,, 143 10th St.
Hyde, Jerome W.
Taintor, G., New England T. & T. Co.
4

Stockbridge.

Field, Stephen D.
1

Worcester.

Kimball, Prof. A. S., Polytechnic Institute.
Webster, Dr. A. G., 936 Main St.
2

MICHIGAN.

Calumet.

Bosson, Fred. N.
1

Detroit.

Blades, Harry H., 1343-55 Cass Ave.
Dow, Alex, 411 Hammond Bldg.
Rae. Frank B., Home Bank Bldg.
Smith, Jesse M., 36 Moffatt Block.
Wilkes, G., 149 Griswold St.
5

Ishpeming.

Mills, Frank P.
1

Springport.

Higgins, Eugene
1

MINNESOTA.

Duluth.

Van Brunt, W., Duluth Telephone Co.
1

Minneapolis.

Brooks, Morgan, 249 Second Ave., So.
Gerry, M. H., Jr. 3333 Cedar Ave.
Morse, Geo. H., 910 Wright Block.
Shepardson, Prof. G. D., University of Minnesota.
4

St. Paul.

Byllesby, Henry M., 403 Sibley St.
1

MISSOURI.

Columbia.

Shrader. Prof. Wm.
1

Kansas City.

Blood, W. H., Jr. 535 Delaware St.
Casper, Louis, Box 257.
Weeks, E. R., National Bank of Kansas City Building.
3

St. Louis.

Durant, Geo. F., 511 No. 4th St.
Kinney, H. A.
Randall, J. E., 1912 Olive St.
Schlosser, F. G., 1038 Leffingwell Ave.
4

MONTANA.

Great Falls.

Morrow, John T.
1

NEBRASKA.

Lincoln.

Owens, Prof. R. B.
1

Omaha.

White, W. F., 309 So. 13th St.
Lane, Vance
2

South Omaha.

Wiley, W. S., So. O. Elec. Light Co.
1

NEVADA.

Virginia City.

Fielding, Frank E. 1

NEW HAMPSHIRE.

Hanover.

Crehore, Dr. A. C.
1

Manchester.

Clough, A. L., Box 114.
Smith, J. Brodie, 142 Merrimack St
2

Nashua.

Spaulding, Hollon C.
1

Portsmouth.

Flanagan, T. F., Portsmouth Gas Light Co.
1

NEW JERSEY.

Bayonne City.

Bennett, E. H., Jr., 17 E. 33d St.
Fleming, Wilfrid H., 70 W. 3d St.
Uebelacker, C. F., 88 Avenue C.
3

Bridgeton.

Smith, Oberlin

1

Bound Brook.

Loomis, O. P.

1

Camden

Harrington, Walter E., 307 Market St.

1

East Orange.

Bauer, W. F., 62 Steuben St.
Flack, J. Day, 80 Carlton St.
Jackson, F. E., 61 So. Grove St.

3

Elizabeth

Diehl, Philip, 508 Morris Ave.

1

Harrison.

Eyre, M. K.
Howell, Wilson S.
Marshall, J. T.
Moore, D. McF., 321 Sussex St.
Page, A. D.
Whittemore, C. F.

6

Hoboken

Cuntz, Johannes H., 325 Hudson St.
Denton, Prof. J. E., Stevens Institute.
Geyer, Dr. Wm. E., " "
Morton, Dr. H., " "
Verley, Horace S. L., " "

5

Jersey City

Curtis, Chas. G., Pacific Ave.
Ockershausen, H. A., 65 Madison Ave.

2

Lakewood.

Stockly, Geo. W.

1

Maywood.

Jaeger, Chas. L.

1

Montclair.

Broadnax, F., 47 Christopher St.
Harrison, Harold

2

Newark.

Anthony, Watson G., 32½ Webster St.
Atwood, Geo. F.,
Mechanic and Lawrence Sts.
Bosch, Adam. Fire Alarm Telegraph.
Colby, Edward A., Lock Box 313.
Doane, S Everett, 68 Park Place.
Donner, W. H., 241 6th Ave.
Gerry, E. M., 114 William St.
Gesseaume, Chas., 29 Plane St.
Heinrich, Richard O., 114 William St.

Newark.—Continued.

Howell, J. W., 761 High St.
Martin, J., 16 Oak St.
Osborne, L. A., 523 Prudential Bldg.
Saxelby, Frederick, 288 Summer Ave.
Weston, Edward, 114 William St.
Wharton, H. M., 800 Broad St.

15

Orange.

Edison, Thomas A.
Upton, F. R. 107 Day St.

2

Passaic.

Alden, James S., 486 River Drive.
Mott, S. D.
Varley, T. W., Okonite Co.

3

Plainfield.

Kinsman, Frank E.
McClurg, W. A., 207 Madison Ave.
Miner, Willard M., 339 East Second St.

3

Princeton.

Brackett, Prof. Cyrus F.

1

Roselle.

Lawton, W. C.

1

Rutherford.

Buys, Albert
Petty, Walter M.

2

Trenton.

Roebling, Ferdinand W.
Elmer, Wm., Jr., 25 Forst Richey Bldg.

2

South Orange.

Delany, Patrick B.

1

Westfield.

Henshaw, F. V., C. and C. Elec. Co.

1

West Hoboken.

Reckenzaun, F., 58 Demott St.

1

NEW YORK.

Albany.

McElroy, James F., 131 Lake Ave.,
Miller, Wm. C., 3 South Hawk St.,
Van Buren, Gurdon C., 84 Clinton Ave,

3

Auburn.

Case, Willard E., 6 Fort St.

1

Bedford.

Luquer, T. T. P.

1

Belmont.

Gorton, Charles.

1

Brooklyn.

Barstow, W. S., 360 Pearl St.
Berresford, A. W., 197 Van Buren St.
Bliss, Wm. L., 24 Irving Place.
Broich, Jos., 448 8th Ave.,
Burnett, Douglass, 42 Livingston St.,
Caldwell, Fordyce S., 151 Henry St.,
Chinnock, C. E., 137 Sixth Ave.,
Dey, Harry E., 342 Tenth St.
Etheridge, E. L., 66 No. Oxford St.
Gerry J. H., 163 Grand Ave.
Halsey, W. B., 246 Elton St.
Hochhausen, Wm., 76 Hanson Place.
Kirkegaard, J. Georg. 351 Jay St.
Leslie, E. A., 343 Hancock St.
Mason, James H., 10 Fifth Ave.
McBride, James, 146 Kent St.,
McCarthy, L. A., 1053 Bedford Ave,
Mosscrop, Wm A., 29 Clifton Place.
Parker, Herschel C., 21 Fort Green Pl.,
Paul, Chas. M., 172 Remsen St.,
Peck, E. F., Cor. Rockwell Pl. and De Kalb Ave.,
Potts, Chas E., 1356 Dean St.
Reilly, John C., 16 Smith St.,
Robinson, F. G., 156 Macon St.
Roller, Lieut. J. E., 515 Clinton Ave.
Sargent, W. D., 16 Smith St.,
Searles, A. L., 291 Seventh Ave.
See, A. B., 116 Front St.
Sheldon, Dr. Samuel, 170 State St.,
Sinclair, H. A., 950 Bedford Ave.,
Sykes, Henry H., 75 Hicks St.
Treadwell, Augustus, Jr., 488 3d St.
Zimmerman, L. J., 57 Penna. Ave.

33

Buffalo.

Haskins, C. H., Superior Court Chambers
Perkins, Frank C., 774 Prospect Ave.
Plumb, Chas., 89 Erie St.
Ricker, C. W., 109 White Bldg.

4

Cortland.

Dunston, R. E.

1

Dobbs Ferry.

Williamson, G DeWitt

1

Elmira.

Wolverton, B. C., N. Y. & Pa. T. & T. Co.,
Cheney, F. A., Elmira Ill'g Co.

2

Garden City.

Archer, Geo. F.

1

Greenbush.

Pratt Robert J.

1

Herkimer.

Lyman. C. W.

1

Ithaca.

Bedell, Fred. Dr., 117 E. Buffalo St.
Bergholtz, H., Ithaca Street Ry. Co.
Glading, F. W., 1 DeWitt Ave.
Lanphear, B. S., 106 Union Ave.
Macfarlane, Prof. Alex., 84 Heustis St.
Matthews, Chas. P., 211 E. State St.
Merritt, Prof. Ernest Cornell University.
Nichols, Dr. E L., Cornell University.
Ryan, Prof. H. J., Cornell University
Sharp, Clayton H., 122 Univ. Ave.

10

Jamaica.

Fleming, R.
Weller, H. W.

2

Jamestown.

Gifford, C. E.

1

Kingston.

Desmond, Jere. A., Electric Light and Power Co.

1

Long Island City.

Shepard, W. E., Steinway Ry. Co.

1

Mamaroneck

Farnsworth, A. J.

1

Newtown.

Proctor, Thos. L.

1

New York City.

Agnew, C. R., 23 W. 30th St.
Alexander, Harry, 126 Liberty St.
Alexander, P. H., 45 Broadway.
Anthony, W. A., 5 Beekman St.
Ashley, F. M., 136 Liberty St.
Auerbacher, L. J., 136 Liberty St.
Ayer, Jas. I., 73 Watt St.
Barberie, E. T., 159 W. 66th St.
Baillard, E. V., 106 Liberty St.
Bartlett. Edw. E., 23 Rose St.
Barrett, John A., 126 Liberty St.
Batchelor, C., 33 West Twenty-fifth St.
Bates, J. H., 126 Liberty St.
Baylis, R. N., 81 Fulton St.
Benjamin, Park. 203 Broadway.
Bennett, J. C., 44 Broad St.
Bethell, U. N., 18 Cortlandt St.
Bijur, Jos. 41 W. 53d St.
Binney, Harold, 38 Park Row.
Birdsall, E T., 18 Broadway.
Bishop, James D., 234 W. 29th St.
Blake, Henry W., 26 Cortlandt St.

New York City.—Continued.

Blizard, Chas., 66 Broadway.
Bogart, A. Livingston, 22 Union Sq.
Bogue, Chas. J., 206 Centre St.
Bohm, Ludwig K., 117 Nassau St.
Boughan, Edward L., 153 Cedar St.
Bourne, Frank, 26 Cortlandt St.
Bradley, C. S., 1919 7th Ave.
Brenner, W. H., 39 Cortlandt St.
Brixey, W. R., 203 Broadway.
Brown, Alex. S., 397 St. Nicholas Ave.
Brown, Alfred S., 195 Broadway.
Brown, E. D., 18 Cortlandt St.
Brown, J. Stanford, 126 Liberty St.
Buckingham, Chas. L., 195 Broadway.
Bunce, Theo. D., Jr., 239 E. 27th St.
Burke, Jas., 203 Broadway.
Caldwell, Edw., 1320 Havemeyer Bldg.
Callender, Romaine, Decker Bldg.
Carichoff, E. R., 253 Broadway.
Carson, David L., 18 Cortlandt St.
Carty, J. J., 18 Cortlandt St.
Chamberlain, J. C., 135 E. 18th St.
Chandler, Prof. C. F., Columbia Coll.
Chase, H. S., 136 Liberty St.
Clark, Ernest P., 192 Broadway.
Clark, Le Roy, Jr., 229 W. 28th St.
Clarke, Charles L., 55 Liberty St.
Coho, H. B., 203 Broadway.
Colgate, Geo. L., 136 Liberty St.
Colvin, F. R., 203 Broadway.
Compton, A. G., 17 Lexington Ave.
Craigin, Henry A., 120 Broadway.
Crane, W. F. D. 87 Maiden Lane.
Crocker, Francis B., 26 W. 22nd St.
Crosby, O. T., 29 Broadway.
Cushman, Holbrook, 337 West 22d St.
Cuttriss, Chas., 1 Broad St.
Dana, R. K., 16 Cliff St
Davenport, C. G., 44 Broad St.
Davidson, E. C., 179 Times Bldg.
Davis, Charles H., 120 Broadway.
Davis, Joseph P., 113 W. 38th St.
Davis, Minor M., 253 Broadway.
Decker, D. H., 5 Beekman St.
Denison, S. P., 143 Centre St.
Dickerson, E. N., 253 Broadway.
d'Infreville, Georges, 10 Desbrosses St
Doremus, Dr. C. A. 59 W. 51st St.
Dressler, Chas. E., 17 Lexington Ave.
Dunbar, F. W., 425 W. 22d St.
Dunn, Gano S., 223 Central Park, West.
Durant, Edward, 39 Cortlandt St.
Dyer, F. M., 10 W. 23d St
Dyer, R. N., 36 Wall St.
Eidlitz, C. L., 10 W. 23d St.
Emery, Dr. Charles E., 95 Nassau St.
Emmet, H. L. R., 36 Cortlandt St.
Fay, Thomas J., 143 Liberty St.
Field, C. J., 26 Cortlandt St.
Fiske, Henry G., 45 E. 22nd St.
Flint, B. P., 120 Broadway.
Foote, Thos. H., 215 W. 125th St.
Forbes, Francis, 32 Nassau St.

New York City.—Continued.

Foster, Horatio A., 35 Wall St.
Freedman, Wm. H., 120 W. 125th St.
Frey, C. P., 5 and 7 Dey St.
Frye, Henry W., 253 Broadway.
Fuller, F. G., 203 Broadway.
Gallaher, E. B., 253 Broadway.
Gardanier, George W., 195 Broadway.
Giles, W. A., 29 Cortlandt St.
Gladstone, J. W., 110 E. 23d St.
Goldmark, Chas J., 49 Liberty St.
Gordon, Reginald, 339 Lexington Ave.
Gossler, P. G., 108 Fulton St.
Graham, Geo. W., 203 Broadway.
Guy, Geo. H., 534 Temple Court.
Hadaway, W. S., Jr., 26 Cortlandt St.
Hadley, W. B., 30 Cortlandt St.
Hall, Edward J., 18 Cortlandt St.
Hall, William P., 80 Broadway.
Hamblet, James, 195 Broadway.
Hamilton, Geo. A., 22 Thames St.
Hammer, W. J., 1305 Havemeyer Bldg.
Harding, H. McL., 253 Broadway.
Hatzel, J. C., 114 Fifth Ave.
Haviland, F. L., 192 Broadway.
Hayes, Harry E., 153 Cedar St.
Hedenberg, W. L., 108 Fulton St.
Herzog, Dr. F. Benedict, 30 Broad St.
Higgins, Edward E., 26 Cortlandt St.
Hill, George, 44 Broadway.
Hix, E. R., 41 Wall St.
Holmes, Franklin S., 108 Fulton St.
Howson, Hubert, 38 Park Row.
Hubbard, Wm. C., 73 Watt St.
Hutchinson, Dr. Cary T., 253 B'way.
Idell, Frank E., 616 Havemeyer Bldg.
Jenks, W. J., 44 Broad St.
Jones, Francis W., 253 Broadway.
Johnston, W. J., 253 Broadway.
Keefer E. S., 22 Thames St.
Knox, James M., 32 W. 129th St.
Knudson, A. A., 106 Fulton St.
Lanman, Wm. H., 44 Broad St.
Ledoux, A. R., 9 Cliff St.
Leonard, H. Ward, 44 Broad St.
Lester, W. B., 195 Broadway.
Levy, Arthur B., 810 Lexington Ave.
Lieb, J. W., Jr., 166 W. 97th St.
Lloyd, Robert McA., 1 W. 39th St.
Lozier, R. T. E., 465 Greenwich St.
Lufkin, Harvey L., 39 Cortlandt St.
Lundell, Robert, 44 Broad St.
Mackie, C. P., 45 Broadway.
MacQuesten, W. D., 15 Cortlandt St.
Madden, O. E., 41 Wall St.
Mailloux, C. O., 45 William St.
Mansfield, A. N., 153 Cedar St.
Marks, L. B., 51 E. 67 St.
Martin, F., Madison Square Garden.
Martin, T. Commerford, 203 Broadway.
Maver, William, Jr., 31 Nassau St.
Mayrhofer, J. C., 165 W. 82d St
McKibbin, George N., 80 Broadway.
Merrill, E. A., 42 Cortlandt St.

New York City.—Continued.

Metcalfe, George R., 343 9th Ave.
Meyer, Julius, 44 Broad St.
Mitchell, John Murray, 35 Wall St.
Monell, Joseph T., 236 W. 22d St.
Moses, Dr. Otto A., 1037 Fifth Ave.
Mustin, H. S., 143 Liberty St.
Noll, Augustus, 8 E. 17th St.
Olan, Theo J. W., 69 W. 49th St.
Osterberg, Max, 232 E. 62d St.
Parmly, C. Howard, 344 W. 29th St.
Parsell, H. V., Jr, 31 E. 21st St.
Pattison, Frank A., 136 Liberty St.
Pearson, F. S., 621 Broadway.
Pedersen, F. M., 327 W. 34th St.
Perry, N. W., 6 Park Place.
Pfund, Rich'd, Room 70, 195 Broadway.
Phelps, Geo. M. 203 Broadway.
Pickernell, F. A., 153 Cedar St.
Pope, Franklin L., 39 Cortlandt St.
Pope, Ralph W., 26 Cortlandt St.
Price, C. W., 13 Park Row.
Pupin, Dr. Michael I., 46 W. 72d St.
Read, Robert H., 39 Cortlandt St.
Reed, H. A., 420 E. 25th St.
Reed, H. D., 420 E. 25th St.
Rennard, J. C., 18 Cortlandt St.
Riker, Andrew L., 737 Madison Ave.
Rittenhouse, C. T., 247 W. 138th St.
Roberson, O. R., 195 Broadway.
Rouquette, W. F. B., 47 Dey St.
Rosenbaum, Wm. A., Times Building.
Rosenberg, E. M., 784 Lexington Ave.
Sachs, Joseph, 32 Nassau St
Scheffler, F. A., 126 Liberty St.
Schreiter, Heinr. 11 Chambers St.
Seely, J. A., 121 Liberty St.
Serrell, Lemuel Wm., 253 Broadway.
Sever, Geo. F., 34 W. 32d St.
Shain, Charles D., 136 Liberty St.
Sheehy, Robert J., 570 Park Ave.
Slade, A. J., 62 E. 66th St.
Smith, J Elliot, 122 W. 73rd St.
Smith, T. Jarrard, 7 Dey St.
Sprague, Frank J., 253 Broadway.
Stieringer, Luther, 68 Broad St.
Stockbridge, Geo. H., 39 Cortlandt St.
Stump, C. E., 26 Cortlandt St.
Taltavall, Thos R., World Building.
Terry, Chas. A., 120 Broadway.
Tesla, Nikola, 35 So. 5th Ave.
Thompson, Edward P., 5 Beekman St.
Toerring, C. J., Jr., 73 Watt St.
Townsend, Henry C., 5 Beekman St.
Turner, Wm. S., 47 Times Building.
Tuttle, George W., 510 W. 23rd St.
Vail, J. H., 39 Cortlandt St.
Vail, Theo. N., 18 Cortlandt St.
Vansize, William B., 44 Broad St.
VanWyck, P. V. R. Jr., 981 Madison Av.
Varley, Richard, Jr., 62 Cortlandt St.
Wacker, Geo. G., 1340 Vanderbilt Ave.
Wardell, Geo. P., 103 E. 10th St.
Warner, Chas. H., 50 Broadway.

New York City.—Continued.

Waterman, F. N., 120 Broadway.
Weaver, W. D., 253 Broadway.
Webb, Herbert Laws, 18 Cortlandt St.
Wetzler, Joseph, 203 Broadway.
Wheeler, S. S., 39 Cortlandt St.
White, H. C., 15 Cortlandt St.
White, J. G., 29 Broadway.
Whitmore, W. G., 44 Broad St.
Wiley, Wm. H., 53 East 10th St.
Wilson, Fremont, 108 Fulton St.
Wintringham, J. P., 36 Pine St
Wolcott, Townsend, 1002 Bennett Bldg.
Wood, E. J., 243 Broadway.
Woodbridge J. L., 47 Times Building.
Woolf, Albert E., 66 Broad St.
Yarnall, V. H., 29 Broadway.
Zalinski, Capt. E. L., 7 W. 43d St.

228

Official Stenographer.

Ryan, R. W., 262 W. 11th St.

Oswego.

Judson, Wm. Pierson

1

Ovid.

Waring, John

1

Pelham Manor.

Gilliland, E. T.

1

Rhinecliff.

Philbrick, B. W.

1

Rochester.

de Lancey, D.

1

Schenectady.

Andrews, W. S., General Electric Co.
Berg, E. J., 53 Washington Ave.
Blood, J. B., General Electric Co.
Cahoon J. B., 226 Union St.
Churchill, Arthur, 5 So. Church St.
Curtiss, Geo. F., General Electric Co.
Greene, S. Dana, " " "
Emmet, W. L. R., " " "
Griffin, E., " " "
Hewlett, Edw. M., " " "
Hobart, H. M., " " "
Kellogg, J. W., " " "
Kirkland, J. W., " " "
Lovejoy, J. R. " " "
Oudin, M., " " "
Reid, Thorburn, " " "
Reist, H. G., 5 So. Church St.
Rice E. Wilbur, Jr., General Electric Co.
Rohrer, Albert L., " " "
Roper, D. W., " " "
Stebbins, Theodore " " "
Steinmetz, C. P., " " "
Wiener, A. E., 208 Liberty St.
Wirt, H. C., 842 Union St.

24

Syracuse.

Brady, Paul T.
Land, Frank, care of Globe Hotel.
Marvin, H. N., 208 So. Geddes St.
Wardlaw, Geo. A., 412 E. Willow St.
4

Troy.

Bernard, Edgar G., 434th St.
Chadbourne, H. R., Jr., Troy City R'y
Parks, C. Wellman, 1825 Fifth Ave.
Stevens, W. Le Conte.
Rensselaer Poly. Inst.
4

Utica.

Hunt, A. L., State Hospital.
Nicholson, W. W., 73 Howard Ave.
2

Waterloo.

Mercer, A. G., Waterloo Electric Co.
1

Yonkers.

Essick, Samuel V.
Ihlder, John D.
Slater, F. R.
3

NORTH CAROLINA.

Wilmington.

Barnard, J. H., Wilmington St. Ry. Co.
1

OHIO.

Akron.

Shaw, E. C.
1

Cincinnati.

Cabot, John A., 123 West 8th St.
Cothren, Wm. H., 164 W. 8th St.
Creaghead, Thos. J., 296 Plum St
French, Prof. Thos., Jr., Avondale
Gray, W. N., 200 Neave Building.
Roberts, W. H., 15 Harrison St.
6

Cleveland.

Black, Chas. N., Belden St.
Brush, Chas F., 453 The Arcade
Canfield, Milton C., 18 Clinton St.
Cowles, Alfred H., 361 Arcade.
McKinstry, J. P., 316 Seneca St.
Roberts, E. P., Brainard Block.
Sperry, E. A., Mason and Belden Sts.
Wason, Chas. W., 1762 Euclid Ave.
8

Columbus.

Caldwell, F. C., State University.
Childs, S. W., Central Railway Co.
Thomas, Prof. B. F., State University.
3

Hamilton.

Cornell, Chas. L.
1

Marietta.

Shedd, J. C., 512 4th St.
1

Salem.

Davis, Delamore L., 299 Lincoln Ave.
1

Steubenville.

Flood, J. F., Steubenville Street Ry. Co.
1

Wyoming.

Lilley, L. G.
1

OREGON.

Portland.

Cheney, W. C., Portland General Electric Co.
Coolidge, C. A., 591 Hood St.
Dame, F. L., The Northwest General Electric Co.
Malcolm, P. S., 131 Sixth St.
Mitchell, Sidney Z., Fleischner B'ld'g.
5

PENNSYLVANIA.

Allegheny City.

Fessenden, Prof. R. A.
Vandegrift, James A., Robinson St.
2

Altoona.

Dudley, C. B., 1219 Twelfth Ave
1

Catasauqua.

Tait, F. M., 731 3d St.
1

Chester.

Arnold, C. R., Arnold Elec. Mfg Co.
1

Erie.

Boynton, E. C., 156 W. 8th St.
1

Germantown.

Condict, G. Herbert, 5328 Green St.
1

Haverford College.

Griscom, Wm. W.
1

Monongahela City.

Acheson, E. G.
1

Nanticoke.

Sanborn, Francis N.
1

Norristown.

Watts, H. F.

1

Philadelphia.

Albright, H. F., 5304 Lancaster Ave.
Billberg, C. O. C., 3200 Arch St.
Blanchard, C M., 1209 Betz Bldg.
Braddell, Alfred E., 316 Walnut St.
Bragg, Chas. A., 302 Girard Bldg.
Childs, A. E., 302 Girard Bldg.
Darlington, F. W., 503 Girard Bldg.
Drysdale, W. A , Hale Bldg.
Eglin, W. C. L., 909 Walnut St.
Flagg, S.G., Jr.,19th St. and Penn. Ave.
Gerson, L. J., 809 Sansom St.
Hering, Carl, 927 Chestnut St.
Hewitt, Chas., 920 Spruce St.
Houston, Prof. E. J.,
1809 Spring Garden St.
Hunter, Rudolph M., 926 Walnut St.
Ives, Lieut. E. B., 421 Chestnut St.
Johnston, A. L., 4300 Lancaster Ave.
Keller, E R., 1210 Betz Bldg.
Kennelly, A. E., 1106 Betz Bldg.
La Roche, F. A., 2235 No. 16th St.
Levis, Minford, 54 North 4th St.
Lloyd, Herbert, Drexel Bldg.
Marks, Prof. W. D., Edison Elec. Lt. Co.
Martin, A. J., 1308 N. 20th St.
Perot, L. Knowles, 308 Walnut St.
Pike, Clayton W., 1210 Betz Bldg.
Reed, C. J., 609 Norris St.
Rowland, Prof. A. J., Drexel Inst.
Sheble, F., 1022 Arch St.
Shields, W. J., 829 Arch St.
Smith, T. Carpenter, 212 Drexel Bldg.
Spencer, Theo., 406 Market St.
Stevens, Prof J. F., 1419 Walnut St.
Uhlenhaut, F., Jr., 4101 Haverford St.
Wendle, Geo. E., 2433 N. 7th St.
Willyoung, Elmer G., 1210 Betz Bldg.
Winand, P. A. N., 3200 Arch St.
Wright, Peter, Drexel Bldg.,

38

Pittsburg

Bliss, Geo. S., Telephone Bldg.
Eden, M. E., 83 Fourth Ave.
Fisher, H. W., Standard Und. Cable.
Floy, Henry, Westinghouse E. & M. Co.
Frost, Francis R., 58 Bluff St.
Healy, L. W. Westinghouse E. & M. Co.
Hutchinson, F. L. " " "
Ingold, Eugene, 1669 Second Ave.
Keller, E. E., 222 Murtland Ave.
Lange, Philip A., West'house E. & M. Co.
McCrosky, J W., " " "
Myers, Geo. Francis, Penn Building.
Phillips, Leo A. West'house E. & M. Co.
Requier, A. M., " " "

Pittsburg.—Continued.

Schmid, A., Westinghouse E & M. Co.
Scott, Chas. F., " " "
Smith, F. S., " " "
Stillwell L. B., " " "
Strauss, Herman A. " " "
Temple, William Chase, P. O. Box 800.
Vanderslise, G. H., P. O. Box 911.
Waring, R. S., 61 Westinghouse Bldg.
Waters, Edward G., 425 Wood St.
Wurts, A. J., Westinghouse E. & M. Co.

24

Rochester.

Shallenberger, O. B.

1

Scranton.

Wightman, Merle J., 11 Library Bldg.

1

South Bethlehem.

Powell, W. H.

1

State College.

Jackson, Prof. J. P.
Lardner, H. A.

2

West Bethlehem.

Lattig, J. W., 335 Broad St.

1

Wilkesbarre.

Seitzinger, H. M.

1

RHODE ISLAND.

Bristol.

Blake, Theo. W.

1

Providence.

Lenz, Chas. O., 510 Ind. Trust Bldg.
Miller, Joseph A., 25 Butler Exchange.
Phillips, Eugene F., 67 Stewart St.

3

SOUTH CAROLINA.

Columbia.

Johnson, J. N.

1

TENNESSEE.

Memphis.

Roessler, Capt. S. W., 99 Madison St.

1

TEXAS.

Austin.

McRae, Prof. A. L., Univ. of Texas.

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Dallas.

Mottram, W. T. M.

1

UTAH.

Salt Lake City.

McKay, C. R., 140 So. Main St.
1

VERMONT.

Brattleboro.

Childs, W. H.
Fuller, Hon. Levi K.
2

Burlington.

Storrs, Prof. H. A.
1

Rutland

Francisco, M. J., Rutland Elec. Lt. Co.
1

VIRGINIA.

Blacksburg.

Randolph, L. S.
1

Fortress Monroe.

Parkhurst, Lieut. C. D.
Squier, Lieut. Geo. O.
2

Front Royal.

Albert, Henry
1

Lynchburg.

Poole, Cecil P., 108 8th St.
1

Norfolk.

Crews, J. W.
1

Richmond

Leonard, M. B., Sup't C. & O. R. R. Tel.
McCluer, C. E., So. Bell T. & T. Co.
Tower, Geo. A., 109 S. First St.
Trafford, E. W., 104 No. 7th St.
4

WASHINGTON.

Everett.

Butler, William C.
Ray, Wm. D.
2

Seattle.

Daft, Leo, Burke Building.
1

WEST VIRGINIA.

Huntington.

Wallace, Geo. S., Box 214.
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Morgantown.

Aldrich, William S., P. O. Box 256.
1

Rome.

Babcock, C. D.
1

Wellsburg.

Brady, F. W.
1

Wheeling.

Sands, H. S., Peabody Bldg.
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WISCONSIN.

Eau Claire.

Bates, M. E., National Elec. Mfg Co.
1

Madison.

Davies, Prof. John E., 523 Carroll St.
Jackson, Prof. Dugald C.
Jones, Prof. F. R., University of Wis.
3

Milwaukee.

Boardman, H. B., 1530 Grand Ave.
1

DOMINION OF CANADA

NOVA SCOTIA.

Baddeck.

Bell, Prof. A Graham.
1

Halifax.

Cogswell, A. R., 34 Bishop St,
Spike, Clarence J.
2

Hazel Hill.

Colley, Benjamin W.
Dickenson, Samuel S.
2

New Glasgow.

Bowman, Fred. A.
1

ONTARIO.

Berlin.

Breithaupt, E. Carl
1

Ottawa.

Ahearn, T.
Dion, Alfred A., 72 Sparks St.
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Peterborough.

Hartman, Herbert T.
Stephens, Geo.
2

Rat Portage.

McCrossan, J. A.
1

St. Catharines.

Thompson, William G. M.

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Toronto.

Langton, John, Canada Life Building.
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Ross, Norman, 65 Front St.
Rutherford, W. M., 63 Front St
White-Fraser, Geo., 28 Toronto St.

5

QUEBEC.

Montreal.

Carus-Wilson, Prof. C. A.
Ross, Robert A , 94 Queen St.
Sise, Charles F., P. O. Box 1918,

3

MEXICO.

City of Mexico.

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1

CENTRAL AMERICA.

GUATEMALA.

Quezaltenango.

Morehouse, H. H.

1

SOUTH AMERICA.

UNITED STATES of BRAZIL.

Para.

da Cunha, Manoel Ignacio,
Empresa Industrial Gram-Para.

1

Rio Janeiro.

Chermont, A. L., 7 Rue da Matriz.

1

WEST INDIES.

JAMAICA.

Kingston.

Wilson, Harry C.

1

AFRICA.

CAPE OF GOOD HOPE.

Cape Town.

Standford, William.

1

ASIA.

JAPAN.

Osaka.

Iwadare, Kunihiko

1

AUSTRALIA.

NEW SOUTH WALES.

Sydney.

Fischer, Gustave J., Public Works Dep't.
Fitzmaurice, Jas. S., 210 George St.
Jones, A. W., care of H. H. Kingsbury.
Spruson, Wilford J., 169 King St.

4

EUROPE.

AUSTRIA.

Vienna.

Egger, E., X. Simmeringstr, 187
Sahulka, Dr Johann.
Technische Hochschule.

2

GREAT BRITAIN.

ENGLAND.

Bolton-le-Moors.

Jackson, Henry.

1

Bristol.

Dobbie. R. S., 43 Wellington Park Clifton.
Eley, Harris H., 88 Colston St.

2

Chester.

Keith, N. S., Sandycroft Foundry.

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Croydon.

Lewis, Henry Frederick William Redlands, 48 Sydenham Road.

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Kingston-on-Thames.

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London.

Forbes Geo., 34 Great George St.
Lorrain. James Grieve,
Norfolk House, Norfolk St., W. C.
Mann, Francis P.
Mordey, Wm. M.,
34 Montserrat Road, Putney.
Parshall, H. F., 38 Parliament St.

London.—Continued.

Preece, Wm. H., General Post Office.
Solomons, *Sir* D. L., 49 Grosvenor St.
Walter, Henry E.
3 Princes Mansions, Victoria St.
Wells, D., Hurstfield, The Avenue, Gipsy Hill
Winslow, I. E., 38 Parliament St.
Wharton, Chas. J., 82 Bond St.
11

Taunton.

Haynes, F. T. J.
1

SCOTLAND.

Glasgow.

Kelvin, *Lord*, The University.
1

Grantown.

Lawson. A. J.
1

WALES.

Cardiff.

Walker, Sydney F., 195 Severn Road.
1

BELGIUM.

Antwerp.

Inrig, Alec G., Rue St. Gommaire, 23
1

Liege.

Albanese, G. Sacco.
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FRANCE.

Creusot.

Stahl, Th.
1

Paris.

Mix, Edgar W., 27 Rue de Loudres.
Thurnauer, Ernst, 27 Rue de Loudres.
Welles, F. R., 46 Ave. de Breteuil.
3

GERMANY.

Berlin.

Bates, F. C.,
Union Elektricitats Gesellschaft.
Flesch, Chas., Allgemeine Elektricitats-Gesellschaft.
Magee, Louis J., Corneliusstr 1., W.
Otten, Dr. J. D., Kleinbeerenstrasse, 21, S. W.

Berlin.—Continued.

Potter, H. N., Steglitzer Str. 10 Parterre
West, Julius H., Handjery Str., 58, Friedenau near Berlin.
6

Hagen.

Entz, J. B., Accumulatoren Fabrik.
1

Munchen.

Voit, Dr. Ernst
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Nuremberg.

Tischendoerfer, F. W.
1

ITALY.

Ivrea.

Olivetti, Camillo.
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NETHERLANDS.

Amsterdam.

Hubrecht, Dr. H. F. R., Nederlandsche Bell Telephone Co.
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1

RUSSIA.

St. Petersburg.

Sventorzetzky, Capt. L., Military Engineering Academy.
1

Addresses Unknown.

Barth-Bartoshevitch
Carroll, Leigh
Cleveland, W. B.
Cobb, John S.
Danvers, A.
Handley, Arthur
Holcomb. E. R.
Moore, John J.
Raymond, Chas. W.
Reinmann, A. L.
Souza, Carlos Monteiro
Stadelman, Wm. A.
Vance, A. S.
Williams, A. S.
Wright, John D.
14

Notice.

The Secretary would be pleased to receive the present addresses of the above.

Total 913.

Discussion in Chicago, Nov. 21st, 1894.

[Mr. L. L. Summers in the Chair.]

A meeting of the western members of the Institute was held in the Physics Lecture Room of Armour Institute. In the absence of the Local Honorary Secretary, Mr. B. J. Arnold, the meeting was called to order by Professor Stine, about thirty members and visitors being in attendance. Upon motion, Mr. L. L. Summers was appointed Chairman. The paper of the evening, "Indexing Electrical Literature," by Professor Shepardson was read in detail by Mr. Fred.DeLand, at the author's request.

Mr. Fred. DeLand:—Prof. Shepardson's paper has very clearly set forth the pressing need of a comprehensive index to the engineering literature of the past as well as the present, to the end that valuable time now spent in vain searching may be saved, and the duplication of unnecessary and expensive work avoided; has outlined the spasmodic efforts put forth from time to time; and has shown how easily a grand work may be accomplished by systematic co-operation. Thus it remains for us to discuss how all interested parties can best act as a unit in accomplishing the desired end.

How can a proper synopsis of all important articles in current publications be most easily obtained? I believe that a concerted effort should be made to have appear in each issue of every technical publication, a brief synopsis of the important articles arranged after the plan shown on the sheets handed to you. At first thought this may seem impracticable, but it will only require a trial in a few issues to demonstrate the value of it both as a time saver, and a seller of the periodical. How greatly it would simplify the work of indexing must be obvious to all. I have occasionally followed this plan in the publication of my magazine, and found that it proved very useful to readers, especially to news-stand buyers, and of some profit to the publisher through increased sales. Every writer for the technical press should be encouraged to send with his manuscript a brief summary of its contents, not exceeding forty words. This the publisher should have arranged something after the following example, and should place it in that portion of the paper that may be scissored without destroying its value for binding:

The Motion of the Ether near the Earth. By Oliver Lodge. Proceedings Royal Institution, Great Britain, No. 86, 1893. Believes the ether does not move; if moving matter disturbs ether in its neighborhood at all, it does so by some minute action, comparable in amount perhaps to gravitation, and possibly by means of the same property as that to which gravitation is due. Not by anything that can fairly be likened to ethereal viscosity. 16p., 10 i.

I propose to follow this plan in coming numbers of *Electrical Engineering*, using a four inch column, bold-face brevier type for title, and nonpareil for author's name, name of publication, and summary of contents, as above. By adopting this size of column it will enable card index owners to clip and paste on cards, or the

slips may be pasted in scrap-books suitably divided, though the card index will probably be found far the most satisfactory. If a majority of publishers of technical journals will only agree to follow a similar plan, it will establish a nucleus for a magnificent index, and one that will prove invaluable to theoretical and practical engineers in the very near future.

PROF. W. M. STINE:—I have read the paper with considerable interest, and possibly can connect it to some extent with a matter in which I was interested some time ago. Mr. Caldwell, who has removed to New York, and myself, some months since discussed with each other the feasibility of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS taking up the subject of indexing current periodical literature. It is almost needless to discuss the demand for this, and it seems but a question of ways and means. We came to no definite conclusion further than that I believe Mr. Caldwell sent out some 200 letters in connection with it. He left for New York soon after and I have lost track of the results of his efforts.

I feel very grateful to the author for bringing the matter to a focus. I have had quite a little experience in this connection in the conducting of a private index, in fact I can scarcely remember a time when the necessity for indexing was not forced upon me. I recognized very early that to become a good student, I must have command of not only the current periodicals, but also of crystallized literature. I made a study of a few forms of indexes that were on the market—blank forms rather—and from them in the manner suggested, I constructed one which I have followed for a number of years with considerable success as far as my own efforts were concerned. Mr. Caldwell informed me that his experience was somewhat similar, that he had even gone further and had employed the services of a stenographer, and had made a brave attempt to form an extensive index. He, however, was forced to give it up, and it is not too much to say that others have been brought to the same conclusion.

It is a matter of considerable interest to me to know what action will result from this paper. The paper before us is a timely one. It brings to a focus a general feeling that some means be taken at once, to enable the student or the busy engineer to compass the whole field of thought and investigation on his subject, and to be permanently master of the matter by being able to refer to it when occasion demands. The prevailing tendency of our time is toward highest efficiencies in all lines. The steam engine within its limits, electrical devices and machinery, manufacturing processes one and all, are receiving the deepest thought, to make them approximate as closely as possible to the ideal efficiency of 100 per cent. But, strange as it may seem, very little attention has been paid to the human mind and working hours at one's disposal, to enable it to work under conditions of maximum efficiency. It may be that human talent and time are so inex-

haustible that from their great abundance, the need of economy, except in cases of individuals is not so apparent. But sporadic attempts in this direction are without doubt giving place to well directed effort, and in no case is this better illustrated than in the consideration of our subject. The enormous activity of thought and investigation has produced a mass of matter utterly beyond the power of any one to compass, even in narrow lines. Like a great business concern, the electrical work must call a halt, and take an inventory to prevent needless waste, and the constant transfer of the same article from debit to credit pages. The relation of cause and effect, and the workings of the human mind are so similar, that the investigator or writer, if he works without reference to what has already been done, will develop the subject, and find on subsequent search that he has done just what others have done before him. It is one of the most singular facts in the action of the human mind that the development of a subject is consecutive and to a great extent independent of the worker. Though so much has already been accomplished, it is but a tithe of what still remains, and it is to be earnestly desired that means be at hand to prevent waste of time by doing what has already been accomplished. But all this is apparent and well understood. There is no need to enter into further detail. It is an absolute necessity to provide some suitable means for utilizing the great mass of facts and wealth of thought on electrical subjects. The question is only one of ways and means to this end.

As the paper intimates, some of us have made attempts at individual references. Some years since I elaborated a system of indexing of the books and periodicals in my possession. I made it a rule not to read either book or periodical which was not worth indexing, but the task is so herculean that it is fast becoming impossible to perform. I feel more and more that the labor spent upon it is unproductive. Not that the index in itself does not repay me, but realizing I am only doing what others are engaged upon, I believe that the subject is one for co-operative rather than individual effort. On the other hand, where I have failed to index, the time spent in searching for the desired article has been annoying and practically wasted.

Our libraries, with their array of bound volumes of periodicals, memoirs, and treatises are practically sealed to all but a favored few, who are so situated that they may take the time necessary to familiarize themselves with their contents.

A universal language would certainly prove a vast boon to the world in saving time and effort. I look upon an index of past and current thought as one of the grandest forms of universal language that can be placed in the hands of the scientific man.

An index to be valuable must be evolved from the expressed needs and opinions of the many. This paper will prove most valuable as a means for bringing out various opinions, and lead to giving precise detail to the varying needs of widely different

classes of workers, even should it not directly result in realization.

Realizing the importance of a full expression of opinion on this subject I have endeavored to formulate my opinion of what an index should be, in order to place it alongside of that of others engaged in different lines.

I cannot agree with Profesor Shepardson in his opinion that both the periodical and literature index be combined in one. This would render the matter unwieldy and eventually defeat the project. I believe that the two should be kept separate and distinct. It still remains to be proven that sufficient co-operation can be secured to render an index possible. Better attempt only one phase at a time until the proper experience is gained, and the public educated up to its support. By all means let the periodical index be the first attempted. Periodical literature is always more or less chaotic. Books may be considered as crystallizations of this literature, and amount in volume to a small fraction of it. The student is still able to handle his books readily, though it may be impossible for him to deal with current writings. If all electrical literature appeared only in the strictly electrical publications, the difficulty of keeping abreast with it would not be so great. But the subject is receiving such widespread attention, that electrical articles of value appear in all classes of periodicals. To render the index then of the greatest value, the entire field of periodical publication must be constantly gone over. This is the scope of the work.

What form should this index take? An index by mere title as has here been pointed out is of little value. The title and author being given, this should be supplemented by as few words of description as possible. The indexer often pays too little attention to the intelligence of his readers, and is needlessly explanatory. In most cases the mere names of subjects treated will prove sufficient. The number of pages of words which the article contains is scarcely worth the trouble and space which it requires. I would in no case advocate abstracts unless they are absolutely necessary. It is needless to seek by an abstract to give the information which the article itself should convey. In order to index an article properly it must be carefully read and the subject matter noted. The subject matter so far as possible in mere mention can then be incorporated with its title, and also used for cross-reference. The feature of cross-references should be as carefully worked out as that of the leading subjects of the articles themselves.

But we must also recognize that in an index we may load the camel until the breaking of its back. Because the subject of electricity has associated with it nearly every other science, and avenue of human activity, many people imagine that an index of electrical literature should embrace references to all other subjects directly or remotely affecting it. A line must be drawn or an

electrical index will become impossible. Let steam engines, die-presses, etc., be cared for in their own appropriate indexes so as to keep the subjects within workable limits. I see no necessity for catering to the demands of partially associated interests.

I also desire to offer some suggestions on matters of detail. Economy of space and time dictates that the matter of the index be as concise as possible. Many current indexes use abbreviations for the names of periodicals which necessitates a key. The name in full and date, though desirable, is by no means essential. I have come to regard a numeral notation as best adapted to this work. Let each periodical be assigned a specific number. Then the index should conclude with the periodical number in heavy bold-faced type; the date in italics; the page in numerals of the face of type employed in the index. For bound volumes the numerical key might be repeated on every even hundredth page, and if issued in parts, the key should be included in each. The index should be issued monthly or quarterly and be also obtainable in yearly volumes.

The same considerations apply to the means for accomplishing the index. The AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS is preeminently a suitable center to undertake the task. A suitably selected committee could adopt a plan and divide the indexing into appropriate headings. It seems that if the work be done at all it must be done by individuals voluntarily, whose work shall be co-ordinated by a central editing committee. I have reason to believe that all publishers will contribute to the enterprise to the extent of contributing at least one copy of their respective periodicals.

The volunteers should be carefully selected by this committee, and one or more subjects assigned to each, with special reference to qualifications for the work. In order to prevent confusion, each person should be assigned one or more periodicals, or, perhaps better, each one be expected to thoroughly index his respective periodicals in accordance with the subdivisions adopted by the committee. I feel certain that the financial portion of the undertaking will receive ready support and be well provided for, once a definite plan is adopted.

MR. L. L. SUMMERS:—There can be little doubt the need of a suitable index is felt, yet experience would seem to indicate that owing to lack of support, as an independent enterprise it can not be made successful financially. Whether this is due to the limited number who have libraries or periodical files extensive enough to warrant subscription to an index, or whether most of the attempts thus far made have been in the nature of a compromise, and have not had support for that reason, it is difficult to decide. It would seem that a compromise of some form must be agreed upon, as an index broad enough in scope to suit perhaps the majority will not be able to contain abstracts of articles which others seem to desire. To my mind it is absolutely necessary,

that in addition to a proper title and the authors name, some idea of the length of an article, its scope, relative importance, or general conclusions be given. This should be very brief and would not necessarily be a digest of the article. If the author's name alone is accepted as a guarantee of merit, much that is valuable from the pens of comparatively unknown writers may be buried through lack of this protective shield, and an appreciation of the value of an article can only be formed by referring to it. That there is a useless waste of time in the individual efforts which have been made, is readily apparent, and it would seem that an investigation on the part of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS might accomplish much, not only in ascertaining the best plan to be followed, but in securing co-operation and in avoiding the necessity for a duplication of individual efforts.

REPORT OF COMMITTEE ON UNITS AND STANDARDS.

[Submitted to Council December 19, 1894, and ordered to be printed in the TRANSACTIONS.]

December 4, 1894.

To the President and Council of the American Institute of Electrical Engineers,

Gentlemen:—Your Committee on "Units and Standards" begs to submit the appended printed copy of an act defining and establishing units of electrical measure in the United States.

The bill was introduced at the second session of the Fifty-third Congress, numbered "H. R. 6500," by the Hon. Charles W. Stone, a Representative of Pennsylvania, who, aided by Prof. T. C. Mendenhall, took an active interest in its progress and passage. On the 30th of March, 1894, the bill was referred to the Committee on "Coinage, Weights and Measures" and ordered to be printed. On the 15th of May, 1894, it was referred to the calendar of the House of Representatives and ordered to be printed, together with the accompanying report, hereto appended. On the 29th of June, 1894, the bill passed the Senate with minor amendments. On the 30th of June the House of Representatives concurred, and on the 12th of July the bill received the approval of the President.

Yours respectfully,

WILLIAM E. GEYER,
GEO. A. HAMILTON,
W. D. WEAVER,
F. B. CROCKER,
A. E. KENNELLY, Chairman.
} Committee.

[PUBLIC—No. 105.]

An Act to define and establish the units of electrical measure.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the passage of this Act the legal units of electrical measure in the United States shall be as follows:

First. The unit of resistance shall be what is known as the international ohm, which is substantially equal to one thousand million units of resistance of the centimeter-gram-second system of electro-magnetic units, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice fourteen and four thousand five hundred and twenty-one ten-thousandths grams in mass, of a constant cross-sectional area, and of the length of one hundred and six and three tenths centimeters.

Second. The unit of current shall be what is known as the international ampere, which is one-tenth of the unit of current of the centimeter-gram-second

system of electro-magnetic units, and is the practical equivalent of the unvarying current, which, when passed through a solution of nitrate of silver in water in accordance with standard specifications, deposits silver at the rate of one thousand one hundred and eighteen millionths of a gram per second.

Third. The unit of electro-motive force shall be what is known as the international volt, which is the electro-motive force that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of an international ampere, and is practically equivalent to one thousand fourteen hundred and thirty-fourths of the electro-motive force between the poles or electrodes of the voltaic cell known as Clark's cell, at a temperature of fifteen degrees centigrade, and prepared in the manner described in the standard specifications.

Fourth. The unit of quantity shall be what is known as the international coulomb, which is the quantity of electricity transferred by a current of one international ampere in one second.

Fifth. The unit of capacity shall be what is known as the international farad, which is the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity.

Sixth. The unit of work shall be the Joule, which is equal to ten million units of work in the centimeter-gram-second system, and which is practically equivalent to the energy expended in one second by an international ampere in an international ohm.

Seventh. The unit of power shall be the Watt, which is equal to ten million units of power in the centimeter-gram-second system, and which is practically equivalent to the work done at the rate of one Joule per second.

Eighth. The unit of induction shall be the Henry, which is the induction in a circuit when the electro-motive force induced in this circuit is one international volt while the inducing current varies at the rate of one ampere per second.

SEC. 2. That it shall be the duty of the National Academy of Sciences to prescribe and publish, as soon as possible after the passage of this Act, such specifications of details as shall be necessary for the practical application of the definitions of the ampere and volt hereinbefore given, and such specifications shall be the standard specifications herein mentioned.

Approved, July 12, 1894.

53D CONGRESS, 2d *Session.* } HOUSE OF REPRESETATIVES. { REPORT No. 901.

UNITS OF ELECTRICAL MEASURE.

May 15, 1894.—Referred to the House Calendar and ordered to be printed.

Mr. CHARLES W. STONE, from the Committee on Coinage, Weights ond Measures, submitted the following

REPORT:

[To accompany H. R. 6500.]

The Committee on Coinage, Weights and Measures, to whom was referred the bill (H. R. 6500) to define and establish the units of electrical measure, respectfully report:

More than 10^9,000,000 (and probably several times that amount) are invested in the appliances for the production and use of electricity and electrical machinery in the United States, and yet there are at the present time no legally defined units or standards for the measurement of this enormous product. Although contracts, involving the expenditure of large sums of money are being made every day for supplying electricity to be utilized as power, light or otherwise, and for furnishing electrical machinery, there are no properly authorized standards by means of which either the seller or the buyer can be protected or to enable the courts to determine definitely when the contract has been fulfilled. This is not owing to the non-existence of suitable units or standards, for in no other department of engineering are the methods of precise measurement so satisfactory as in this.

Units of electrical measure which have been used in scientific investigations for more than a decade have come into use in the practical application of elec-

tricity and have been accepted as necessary and sufficient in all countries. A formal international agreement upon the names and precise definitions of these units was necessary before it was desirable to fix them by legislative enactment. This agreement has now been reached after several preliminary conferences, and is to be found in the official report of the Chamber of delegates of the International Congress of Electricians, held at Chicago in August, 1893. The Chamber consisted of delegates officially representing all the leading nations of the world—the United States, Great Britain, France and Germany being represented by five delegates each, and other nations by a smaller number.

At the end of the conference of the delegates, which extended through a week, it was unanimously resolved "that the several governments represented by the delegates of this International Congress of Electricians be, and they are hereby, recommended to formally adopt as legal units of electrical measure the following:"—the names and definitions of the eight units being then given as in the bill herewith reported.

The names of these units are in all cases derived from those of distinguished electricians. No name of a living man has been used, and those who have contributed most to the development of the science have been selected, some attention being also given to their distribution among the several great contributing nations. Nearly all of these names have been long in use and all have become fixed in the literature of the subject. The three most frequently used are the ohm, ampere and volt, being the units of resistance, current strength and electro-motive force or pressure, respectively. The *ohm* is named in honor of a distinguished German, born in the latter part of the last century; the *ampere* is named for the Frenchman of that name, who so greatly enriched the science of electricity in the early part of the present century; the *volt* is named for Volta, the Italian contemporary of Galvani.

Following these are the *coulomb*, named for a French electrician of the last century; the *farad*, in honor of the celebrated Faraday; the *joule*, in honor of another English scientist, James Prescott Joule; the *watt*, for James Watt, the inventor of the steam engine, and also eminent in electrical investigation, and, finally, the *henry*, in which a place is provided in this splendid galaxy of physicists for our own Joseph Henry, whose electrical researches well deserve to rank with those of the most famous of any age.

These units form a complete and accurate system of electrical measurements, and their legalization by act of Congress is earnestly desired by all electricians and those interested in the manufacture of electrical machinery or the use of electricity. It is imperatively demanded as a means of protection for the rapidly increasing number of consumers of electricity, and it is also urged by those engaged in the production.

It is also important to the Government, which is itself a large and constantly increasing consumer of electricity and electrical machinery, that authoritative units of measure be adopted. This has been fully recognized by the superintendent of standard weights and measures and by the Secretary of the Treasury, and the units of measurement defined in this bill have already been formally approved by them and adopted for Government use.

This departmental action should receive legislative approval, and, beyond that, the necessities of commercial use, as well as the convenience and accuracy of scientific investigation, require the establishment of authoritative units of electrical measure.

The system embraced in this bill, having received the unanimous approval of the representatives of all the nations participating in the recent international Congress of Electricians held in Chicago, it is believed will be adopted by the other nations of Europe and America and become a uniform and international system.

As the congress formulating this system was held in the United States and presided over by one of her most distinguished scientists, it will be a matter of pride for this country to lead in the formal and legal adoption of this system, and your committee recommended the prompt passage of this bill.

Two or three clerical errors should, however, be corrected, and the committee recommended that it be amended by striking out the words "ten and nine-tenths" in the sixth line, and inserting "one thousand million," and in the fortieth line strike out the words "ten and seven-tenths," and in the forty-fifth line strike out the same words, and each instance insert in lieu of these words striken out the words "ten million."

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

December 19th, 1894.

The 92d meeting was held this date at 12 West 31st Street, and was called to order at 8 P. M. by President Houston.

The Secretary read the minutes of the last meeting, which on motion were approved.

The Secretary read the following list of associate members elected and transferred at the Council meeting, held in the afternoon.

Name	Address	Endorsed by
BLACKALL, F. S.	N. Y. City Representative Crocker-Wheeler Elec. Co., 126 Liberty St., N. Y. City.	Jos. Wetzler. Ralph W. Pope. T. C. Martin.
DERYCKERE, G.	Professor in Electrical Engineering. Gand University, residence, Boulevard Frere Orban 18, Gands Belgium.	A. G. Inrig. G. Sacco Albanese. R. W. Pope.
DEY, HARRY E.	342 Tenth Street, Brooklyn, N. Y.	H. Ward Leonard. Jos. Wetzler. Geo. W Tuttle.
GRAHAM, GEORGE WALLACE	Secretary, Interior Telephone Co., 203 Broadway, N. Y.; residence, 163 Hicks Street, Brooklyn, N. Y.	Ralph W. Pope. T. C. Martin. Geo. M. Phelps.
LANE, VANCE	Manager and Supt. Construction, Nebraska Telephone Co., Omaha, Neb.	Thos. D. Lockwood. T. B. Doolittle. Wm. S. Ford.
LARDNER, HENRY ACKLEY	Instructor in Electrical Engineering. State College, Pennsylvania.	J. P. Jackson. D C. Jackson, J. G. White.
MOSES, PERCIVAL ROBERT	Student of Electrical Engineering, Columbia College, N.Y.; residence, 46 West 97th Street, New York.	F. B Crocker. Geo. F. Sever. W. H. Freedman.
PRATT, CHARLES A.	Electrical Engineer, The Independent Elec. Co., 39th Street and Stewart Ave., Chicago, Ill.	Elmer A. Sperry. Chas. N. Black. E. P. Roberts.
PRIVAT, LOUIS	Electrician, Cicero Water, Gas and Electric Light Co., Oak Park, Ill.	Albert Scheible. Fred DeLand Geo. Cutter.

SHEDD, JOHN C.	Professor of Physics and Applied Electricity, Marietta College; residence, 512 Fourth Street, Marietta, Ohio.	Ernest Merritt. Frederick Bedell. Harris J. Ryan.
VANDERSLICE, G. HAMILTON	Westinghouse Electric and Mfg. Co., P. O. Box 911, Pittsburg, Pa.	L. B. Stillwell. Chas. F. Scott. Alex. J. Wurts.

Total, 11.

TRANSFERRED FROM ASSOCIATE TO FULL MEMBERSHIP.

Approved by Board of Examiners, October 5, 1894.

REIST, HENRY G.	Designing Engineer, General Electric Co., Schenectady, N. Y.
TRAFFORD, E. W.	Electrical Engineer, Richmond Railway and Electric Co., 104 N. 7th St., Richmond, Va.
JACKSON, HENRY	Telegraph Superintendent and Engineer, The Lancashire & Yorkshire Railway Co., Horwich, Bolton-le-Moors, Lancashire.
ROUQUETTE, WILLIAM FREDERICK BLAKEWAY	Proprietor Rouquette & Co., 47 Dey Street, N. Y.
UHLENHAUT, FRITZ, JR.	Electrical Engineer, Philadelphia Traction Co., Philadelphia, Pa.

Total, 5.

Report of Meeting of Board of Examiners, December 17th, 1894.

Present—Messrs. G. A. Hamilton, *Chairman*; C. O. Mailloux and E. P. Thompson; R. W. Pope, Secretary, present *ex officio*.

	Approved.	Disapproved.	Laid over for further consideration.	Total Considered.
Applications for Transfer Reconsidered.	11		2	13
New Applications for Transfer Considered.				
Totals.	11		2	13

THE PRESIDENT:—There being no other business, the next matter as announced, will be a paper by Mr. Ludwig Gutmann of Chicago, entitled, "The Production of Rotary Magnetic Fields by a Single Alternating Current." As the author is not here, Dr. Pupin has kindly agreed to present the paper.

[See page 819, December issue.]

Discussion in New York.

Dr. M. I. Pupin:—The author states in the introduction that his paper contains a discussion of a method of generating a rotary magnetic field by a single alternating current without condensers or choking coils, and its application to the construction of single phase alternating current induction motors.

Figs. 1 and 2 show diagrammatically the principle of the devices. An armature core, uniformly wound with wire and the winding divided into a number of closed sections, preferably equal to each other, but in such a way that the number of these sections is not equal to the number of poles of the exciting field. The field is an alternating field. Figs. 4 and 6 illustrate what the author calls the *stable* and the *unstable* positions of magnetic equilibrium of a coil in an alternating field. In the first place a slight displacement of the armature would cause it to oscillate about the line of symmetry between the two poles. In the second case such a displacement would cause the armature to flop over and rotate toward the position of stable equilibrium. An armature winding as that in Fig 2 has also a position of stable magnetic equilibrium about which it will oscillate if slightly displaced. So for instance the position represented in Fig. 2 is an unstable position. A mechanical impulse will start the armature to rotate toward the position of stable equilibrium, and during its journey toward that position it will be also acted upon by the repulsive force between the alternating field and the armature current induced by that field. The armature, therefore, reaches the position of stable equilibrium with a certain amount of kinetic energy which is equal to the energy of the mechanical impulse imparted to it, and the work done upon it by the repulsive force. With this stored up energy, the armature is enabled to continue its journey beyond the position of stable magnetic equilibrium although from this point on it has to move *against* the electromagnetic forces, at the expense of its kinetic energy. How far it will continue this journey will depend entirely on the kinetic energy with which it started from the unstable position, how much work was done upon it by the variable field during its journey from the unstable to the stable position, and at what rate it has to expend its kinetic energy after passing this position.

Three cases must be carefully distinguished:

1st. The armature arrives at the position of stable magnetic equilibrium with less kinetic energy than the amount required to carry it beyond this position and up to the next position of unstable magnetic equilibrium. In this case it will oscillate about the stable position and be finally reduced to rest.

2d. The armature arrives at the position of stable magnetic equilibrium with enough kinetic energy to carry it beyond this position and up to the next position of unstable magnetic equilibrium, but unfortunately it arrives there with less kinetic energy than it had in parting from the preceding unstable position. In

this case it will generally continue to rotate several times around, and be finally reduced to rest.

3d. The third possible case is the most important one and forms the groundwork on which Mr. Gutmann proposes to raise a new system of electrical distribution. It is this: Suppose the armature receives from some external source a certain initial speed, and is then left to take care of itself. Suppose again that this speed is such that the kinetic energy with which the armature passes through a position of stable magnetic equilibrium is considerably more than necessary to carry it to the next position of unstable equilibrium, so that the armature reaches this position with more kinetic energy than it had when it left the last position of unstable equilibrium. It is evident that in this case the armature will not only continue to rotate, but that it will rotate with continuously increasing angular velocity. This initial speed the author calls the *critical speed*.

The question arises now, how long will this continual increase in angular velocity go on? Evidently until synchronism is reached, that is if the armature does no appreciable external work during its rotation. In a bipolar machine with three armature coils the synchronous rotation is illustrated in diagrams Fig. 8. During one reversal of the field the armature has moved through 180°, so that the triangle 1, 2, 3, in B has its sides parallel to the triangle 1, 2, 3 in A. During the next reversal the armature has reached its initial position again, as given in C. But if the armature cannot reach synchronism on account of the external load, or on account of too large frictional resistances, then the best it can do is to rotate at some other lower but constant speed, and the question arises, is any other speed possible? The answer is in the affirmative, for if you look at Fig. 9 you will see that if the speed of the armature under consideration is such that it will carry the armature through one-third of the circumference during one reversal of the field, that the armature can go on rotating at this constant speed. This speed Mr. Gutmann calls *harmonic* speed. Another harmonic speed is illustrated in Fig. 10. Here the armature passes through one-sixth of the circumference during one reversal of the field, so that during three reversals of the field the armature has gone through one-half revolution. The possible speeds of this armature are, therefore, 1, or 2, or 3 revolutions for the time interval corresponding to three complete periods of the exciting field. We can now generalize as follows:

An armature containing n coils will have n *harmonic speeds*, that is to say, it can rotate 1, 2, 3, . . . n times during the time interval corresponding to n complete periods of the exciting current. But it must be remembered that for a given value of the impressed electromotive force and a given mechanical force acting on the shaft of the armature there is, according to the Principle of Conservation of Energy, only one speed at which the armature can rotate uniformly, and if that speed is below the

lowest harmonic speed, the armature will stop. We can say, therefore, that the critical speed is equal to the lowest harmonic speed. If the lowest harmonic speed should be too high for practical working, we can evidently reduce it to any practical limit by using a multipolar field, as an inspection of Figs. 11 and 12 will show.

There is another way in which the forces acting between the field and the armature can be pointed out, and that is, by pointing out the reactions between the exciting alternating field and the magnetic field produced by the induced currents in the armature. It does not make the subject any clearer, and I shall consider it in so far only as necessary to bring out a rather interesting fact. Consider the armature in Fig. 2. Suppose we had one closed coil only, covering $\frac{1}{n}$th part of the armature, and suppose, also, that the field is constant. If the armature is rotated, an alternating current is generated in it, whose frequency is equal to the frequency of rotation of the armature. If, however, while the armature is rotating uniformly, the field alternates uniformly also, then two alternating currents are generated in the coil, one whose frequency is equal to the sum of the frequencies of the armature and field, and the other whose frequency is equal to the difference of these two frequencies. The current of lower frequency has a smaller amplitude than the one of the higher. Its amplitude is zero when the field and the armature are in synchronism, and then the frequency of the other is equal to twice the frequency of the field. If now we cover the whole armature with n equal short-circuited coils by simply connecting, as Mr. Gutmann does in Fig. 2, n successive equidistant points to each other, we shall then have n pairs of alternating currents differing from each other in phase by $\frac{1}{n}$th of the period. They will, therefore, give, theoretically, two rotary magnetic fields. One rotating with a frequency equal to the sum of the frequencies of the armature rotation and the frequency of the alternating field, and the other rotating with a frequency equal to the difference of these two frequencies. At synchronism the slower rotary field vanishes, and the speedier, rotates with twice the angular velocity of the armature. Mr. Gutmann evidently neglects the slowly rotating field, and he may be right. But, however that may be, it is certainly plain that a rotary magnetic field is established by Mr. Gutmann's device, and that we could obtain by a suitable arrangement polyphase currents from such armatures. It is also plain that such a motor could be employed as a motor generator. These appear to me to be the novel features of Mr. Gutmann's proposition. The proposition is certainly interesting. Let us hope that Mr. Gutmann will soon succeed in proving its practical value.

THE PRESIDENT:—Gentlemen, you have heard Dr. Pupin's able exposition of this paper. It is now open for discussion.

MR. WOLCOTT:—I would like to ask one or two questions. On page 828 it says the motor allows magnetic slippage; in other words, it works like an ordinary induction motor. In an ordinary induction motor, in synchronism, the torque is zero, or at all events, it is minimum. It is the same here. Put on a load and get the armature running at a little slower speed than synchronism, the polyphase principle begins—the current induced in the armature makes the pull stronger. Well, if I understand the thing, that is also true of the harmonic speeds. Therefore, starting from the synchronous speed, dropping down to the first harmonic speed, there must be a point where, after there is a certain amount of slip, it drops suddenly to the harmonic speed, because if the harmonic speed works in that respect like a synchronous speed, there must be a tendency either side of it to approach it. That is, if you are going a little faster than the harmonic speed, the tendency is to pull down, and as you go slower again the tendency would be to bring it up again. Is that correct?

DR. PUPIN:—I don't think so.

MR. WOLCOTT:—Would the torque go on increasing infinitely?

DR. PUPIN:—No, because as the armature increases its angular velocity the torque varies; it may diminish. The torque must have a certain value, otherwise it is not able to overcome the mechanical pull on the shaft.

MR. WOLCOTT:—That is very true. But, if I understand this motor, it has two separate components. That is, it works like the ordinary synchronous motor, and then, in addition, it works like the polyphase motor—induction motor.

DR. PUPIN:—Yes, that is right.

MR. WOLCOTT:—Considering the portion of the torque which is due to the synchronous action, the instant you get out of synchronism, as with an ordinary synchronous motor, it stops.

DR. PUPIN:—Not quite so.

MR. WOLCOTT:—Now with this one, as soon as you get out of absolute synchronism, then you depend on the induced currents in the armature.

DR. PUPIN:—The pull between the armature and field, changes rather suddenly; that is, it is a sort of harmonically varying function.

MR. WOLCOTT:—As the speed lags a little, the torque increases, does it not?

DR. PUPIN—Not necessarily.

MR. WOLCOTT:—It does not do the work of an induction motor then? If it does not do that it seems to me that it is no good.

DR. PUPIN:—It has a fair torque at definite speeds only.

MR. WOLCOTT:—The author says it allows similar magnetic slippage.

DR. PUPIN:—Magnetic slippage from the synchronous speed to the next harmonic speed, and then to the next and next, and so on. It does not allow a gradual slippage.

MR. WOLCOTT:—I understand the author to say that it works like a polyphase motor.

DR. PUPIN:—In the sense that it has more than one speed at which it can work. It can work at two or three speeds, practically any number of speeds, if you increase the number of sections in the armature.

MR. KENNELLY:—If I understand the paper correctly, there are certain speeds called harmonic speeds at which the torque is a maximum. In the polyphase motor at certain speeds the torque is zero. So that this action is different altogether from the action of a polyphase motor.

DR. PUPIN: That is my idea of it.

MR. WOLCOTT:—On page 828 he says: "Second, that therefore "it is more difficult to pull it out of step, as it has the capacity to "stand what I would term magnetic slippage." If that means anything it means that if you pull it a little out of step the torque increases. If the torque does not increase, I do not see how it is any more difficult to pull out of step than the ordinary synchronous motor.

DR. PUPIN:—Because, if you pull it out of one step you get it into another.

MR. WOLCOTT:—That may be what the author means, but if it is I think that is a very poor foundation for his claim.

DR. PUPIN:—It has several chances; whereas the ordinary synchonous motor has only one.

DR. SAMUEL SHELDON:—I wish to say a word in reference to the currents generated in the different coils upon the ring of the armature. Suppose the armature to rotate n times in a second in a constant field of unit strength. At any instant of time t, the electromotive force generated in a single coil would be proportional to the sine $2\pi n t$. If the armature remain at rest and the bipolar field should alternate harmonically n' times per second, the electromotive force generated would be proportional to sine $2\pi n' t$. If now the armature should rotate and, at the same time, the field should alternate, the electromotive force produced would be proportional to the sine of $2\pi n t$ times the sine of $2\pi n' t$. Suppose the armature to rotate at that harmonic speed which makes the ratio of n to n' as 2 to 3. The graphic combination of two sine curves of these frequencies yields a third curve, which represents the time change of electromotive force generated in the coil. In this case there is a succession of alternations at two different frequencies. One complete alternation at a certain frequency is followed by another complete alternation at twice that frequency. I do not know what mechanical action would result from this.

DR. PUPIN:—I suspected the difficulty which Dr. Sheldon mentions. The two currents are of unequal amplitude. The one of lower frequency has a smaller amplitude than the one of higher frequency, and Mr. Gutmann seems to rely for the total

action upon the quicker field. Whereas, really, when you have two alternating currents of unequal frequencies, and they are magnetizing iron, then although the current of lower frequency may have a smaller amplitude, it may produce a stronger magnetic effect than the other current which has a higher frequency and larger amplitude and weaken considerably its magnetic effect. That may give Mr. Gutmann some difficulty. I must confess, however, that I have not examined the proposition thoroughly enough to speak with much definiteness.

THE PRESIDENT:—Is there any other discussion of this paper? It may interest the members of the INSTITUTE to know that Council this afternoon took an action which resulted in the appointment of a committee consisting of Prof. Crocker as Chairman, Prof. Kennelly, Mr. Caldwell, Mr. Stine and Prof. Shepardson to discuss and formulate a plan to determine whether or not it is advisable for the INSTITUTE to undertake the indexing of electrical literature. This grew out of the discussion which you remember we had at our last meeting here. I do not know whether the INSTITUTE would care to discuss the matter prior to the work of the committee. This committee is charged with the duty of determining whether such a thing is desirable, and second if it be desirable, to formulate a plan according to which it best can be carried out.

[Adjourned.]

DISCUSSION IN CHICAGO.

A meeting of the Western members of the INSTITUTE was held in Armour Institute on December 19. The meeting was called to order by Mr. Arnold, about thirty-five members and visitors being present. Mr. L. L. Summers was appointed Chairman.

Mr. Gutmann's paper was read in detail by the author.

MR. CARL K. MACFADDEN:—I have had the good fortune to witness a number of experiments that have been made on this system, and I would say that in this new plan, as is stated in the last clause of this paper, it will find a wide field of application. As far as I know there is no method of obtaining polyphased currents in any manner which will ensure a definite relation between the phases of the currents. The method here shown for getting a direct current from a single phase alternating current through a single machine is undoubtedly of great value. One of the drawbacks to the distribution of alternating current for power is the necessity for having more than two wires, and having special generators for furnishing such a current. If our simple single-phase apparatus could be used and a current obtained which might then be converted into polyphase or direct currents, I think that we would find it very desirable.

MR. L. L. SUMMERS:—In the rotary transformer it is evident

that as the motor has several speeds, the dynamo end, if used to develop polyphase currents, would be liable to furnish currents of variable frequency under variable load. The question of the efficiency of the motor, which is a most important one, would seem to depend upon the magnitude of the opposing forces which are represented in triangular figures. I should like to ask Mr. Gutmann what the efficiency would probably be in practice.

MR. GUTMANN:—In a motor it is desirable to have several speeds or many speeds changing gradually. This characteristic is however not essential or even desirable in a rotary transformer, especially if polyphased currents are to be distributed. We would select an armature construction which would have the tendency of retaining a fixed speed, and which is not easily thrown out of step, so that the frequency of the polyphased currents would remain constant.

The efficiency of the motor depends entirely on the construction of the armature, and also on the field. This should not be judged by the diagram, which is simply a convenient mode of illustrating the idea. It is of course understood that in any motor the internal waste of energy should be reduced to a minimum, and in the present case in proper machines the reactive force can be made very small.

MR. MACFADDEN:—One of the most interesting feature of this system to me is the method of obtaining polyphased currents of any number of phases from a single phase alternating current, a single armature and a single winding. From a second winding a direct current might be obtained. Mr. Gutmann has suggested that the whole thing can be done in one armature, which I understand would not be a difficult matter to design. The principle involved is one that I think is applicable to almost all classes of alternating work, and I see many advantages in it from my way of looking at it that are not possessed by any polyphased system

MR SUMMERS:—In a rotary transformer for obtaining direct currents there would also seem to be drawbacks, for if an increased load were put upon the secondary, it would of course load the motor, and if this load is greater than the motor will carry at synchronous speed it would immediately drop to an harmonic speed, and if no system of compensating for the decreased speed is used, the motor would of course remain at this speed without difficulty as the power required would be less, and the torque at an harmonic speed would naturally be greater than at a synchronous speed, providing the power developed is the same. This decrease of speed of course causes a decreased output from the secondary. But suppose a method of compensating for this decrease be obtained, the load would not then be diminished by the decreased speed, and unless the motor is capable of delivering an increased power at the lower speeds, it would behave like an overloaded synchronous motor. What advantage

would there be, Mr. Gutmann, in using this transformer say in place of a self-starting single phase machine connected with a direct current dynamo?

MR. GUTMANN:—A system of compensation may be adopted, as for instance, the placing of the field magnet c in series with the line, which would by its increased strength on increased load superimpose an E. M. F. on the armature conductors, compensating for the decreased speed. As regards a synchronous motor driving a direct current machine of any size, it will be clear that a third machine must be used for starting the synchronous motor, or at least some complicated devices, such as condensers, reactive coils or the like. This complicates a system considerably, and I think a self-contained device will at all times be preferred. This advantage will be appreciated for instance if we wish to supply continuous currents for long distance railway transmissions, overcoming the distance by high potential alternating currents. The sub-stations would each contain but a single rotary transformer, while with the former disposition, a starting device, a synchronous motor and a continuous current generator, or three separate machines, would be required to replace the motor generator.

THE CHAIRMAN:—We have heard an interesting paper this evening, dealing with a subject of great practical importance. I think we all regret that Mr. Gutmann has been unable, or rather unprepared, to furnish data which would enable a comparison to be made with the present methods in vogue both as to practicability and efficiency.

[Adjourned.]

[COMMUNICATIONS RECEIVED AFTER ADJOURNMENT.]

PROF. ELIHU THOMSON:—(*communicated*): In the winter of 1887-88, I made an alternating current motor for single phase currents having a pair of single phase energizing coils surrounding the revolving iron mass, upon which latter three coils were wound as is the ordinary three-coil winding of a Thomson-Houston arc dynamo. This machine with its three coils closed, was without starting torque and was therefore provided with a commutator which short-circuited the coils while in proper position successively. This gave the desired starting torque. It was found that the coils after starting could be short-circuited and the commutator dispensed with. So far as I am aware this machine differed in no essential particular from Mr. Gutmann's, Figs. 1 and 2 of which disposition he evidently believed himself the originator.

He refers to such machines as "having a small starting torque *when rotated.*"

Surely a torque exhibited only after rotation is given is not a *starting* torque, though it may be an accelerating torque, provided there is little friction and no load.

It is not unusual for single phase induction motors to exhibit

such accelerating torque, and I have made many of them in which the relations of windings were very different from those referred to by Mr. Gutmann which gave similar results as the author points out. Such machines will not, of course, start from a state of rest unless some modification of the structure or its mode of operation be made with the purpose of securing starting torque. Some of such methods give starting torque quite comparable with the torque exhibited, while running under full load.

It has been, and is the practice of the General Electric Company to construct both polyphase and single phase induction motors with a three-coil winding on the induced or revolving part, kept on closed circuit through a resistance at the start, and on short-circuit at speed. Mr. Gutmann claims as a point of novelty in his described apparatus "that the closed circuits do not coincide in number with the poles of the field magnet." My original machine, which, by the way, has been described in publications and patents, had two poles and three closed armature coils. This has not been novel since 1888.

The apparatus which Mr Gutmann alludes to in connection with his Fig. 18, seems complicated. Involving, as it does, two commutators, one of them directly in the alternating current supply circuit, it would hardly appear to present any advantages over the motor generators, now well-known in the art, which receive alternating currents of single or polyphased character and commute them into continuous currents by the inevitable single commutator.

Mr. Ludwig Gutmann (*communicated*):—Noticing that the discussion in Chicago is incomplete and that in New York calls for a reply containing similar statements, I have condensed the two in order to answer the questions of several members in the East.

I wish to express at this place my thanks to Professor Pupin for his able exposition of the paper. The differences which, however, exist between a few of his views expressed in the discussion, and my own are due mainly to his strict adherence to the armature diagrams, Figs. 1 and 2, and this adherence, while correct, is caused no doubt by the omission of certain parts which were left out with a view of shortening the already lengthy paper. I wish to remark further that these armature diagrams were selected on account of the simplicity which they admit in presenting the various actions and results of each winding or coil, while for efficient working a number of other dispositions would suggest themselves.

Mr. Wolcott has grasped the situation. The qualities which are shown around the synchronous speed are repeated at the harmonic speeds, which are positions of torque and not dead points, as Mr. Kennelly has assumed. Near synchronism, or at the harmonic speeds, the armature is in stability, and it takes power to pull it out of step; however, when the speed is changing from a given speed into another, the armature is temporarily

in instability until the current has adjusted itself to the new speed.

Both Mr. Wolcott and Dr. Pupin are correct in their assumptions, inasmuch as the motor can either be synchronous or practically so-called non-synchronous. This will be clear if we select, for instance, Professor Ferraris' cylinder armature. (See Fig. 19.) This cylinder, disk or drum has in all positions a symmetrical relation to the energizing field, and the same magnetic resistance to the lines of force of the field contrary to Figs. 1 and 2. Therefore, it may be considered in step at any speed and in any position. This is caused by the continuity of the conductor in the direction of rotation, which allows the greatest possible slippage, owing to the absence of strongly defined poles, and the armature may come to rest in any position in the energized field. Such an armature can rotate at any desired speed which in a given energizing field depends on the load. The greater the load, the smaller the speed, and the greater becomes the amount of energy wasted in the latter by heating. Figs. 1 and 2 show a few interconnected coils, while the Ferraris armature repre-

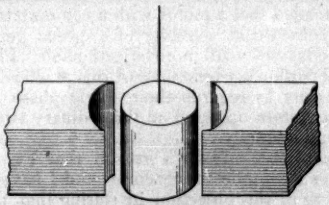


FIG. 19.

sents one of an infinite number of closed coils. The former develops strongly defined poles at given points, and nowhere else, while the cylinder will produce weak poles at any given point of its circumference. The armature, Fig. 2, will, therefore, rotate at certain fixed speeds and not at another, half way between any of the former. Between these two extreme cases belong those types with any other number of coils or circuits which may be designed for either speeds, changing abruptly or gradually. The greater the number of armature conductors or coils the smaller will be the difference of change from one speed to the next.

The remarks of Drs. Pupin and Sheldon regarding the action of the slower field are very pertinent. Certainly this second field may become detrimental in some machines; however, this fact has been recognized at an early stage. To make any motor efficient, reactive forces should be as small as possible, and they can be reduced to a few per cent. of the main force in machines of this type.

In reply to Professor Thomson I wish to say that the communication regarding his motor construction is something new to me. Looking over a number of references relating to the professor's motors, I have failed to find an armature with closed sub-circuits, which has been used since 1891, especially in polyphase work. Had I known that I would raise a question of priority, I would have carefully avoided it. Should I be mistaken in this matter, and it be found that the devices are identical, which question is an open one, I would only be too glad to repair the error. The criticism regards "starting torque" is correct, accelerating torque is the proper term.

The practice of the General Electric Company is widely known, and while I have read of their polyphase and so-called monocyclic systems, I must confess that I have not heard or read anything in technical journals regarding the single phase motors and their installations, except perhaps the fan motor, the outside of which was described last year. Had the power motors given the desired results, I do not understand the unnecessary expense of the creation of the monocyclic system within the last six months. It may be contended that a motor with a commutator is objectionable, but I believe the necessity of a special generator and an additional conductor is still more objectionable. I hope Professor Thomson will pardon my ignorance of this practice of the General Electric Company as regards their single phase motors, which are no doubt motors operated on the ordinary two-wire circuits, if I understand correctly.

Ifully agree with Professor Thomson that Fig. 18 would be for many cases a complicated machine, and I have tried to prevent the raising of this objection by stating that the device has been simplified to a considerable extent. It was not the object to show these devices up to date, but to show that the ordinary single phase alternating current can be split up at any point into any number of phases lagging at a constant angle, which, to my knowledge, has not been done heretofore, and secondly, that a constant current can also be produced by such a machine, also at any point of the ordinary circuit. The state of the art has been, as far as I am aware, to commutate a single alternating current into a pulsatory one by means of a commutator rotated synchronously, or by leading into a motor generator bi- or polyphased currents and commutating these into continuous currents. However, neither the method of changing a single alternating current into a continuous current, "now well known in the art," to which Professor Thomson refers, nor the machine accomplishing it, are known to me.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

New York, January 16th, 1895.

The 93d meeting of the INSTITUTE was held this date at 12 West 31st street, and was called to order by President Houston at 8 P. M.

The Secretary read the minutes of the last meeting which on motion were approved, also a list of associate members elected at and transferred at the last Council meeting, as follows:

Name.	Address.	Endorsed by.
ANDERSON, HENRY S.	General Manager and Electrician, United Electric Light Co., Springfield, Mass.	Geo. W. Blodgett. W. Stanley. W. L. Robb.
BUCK, H. W.	Student in Electrical Engineering, Columbia College; residence, 14 E. 45th St., N. Y. City.	F. B. Crocker. G. F. Sever. C. T. Rittenhouse.
COX, EDMUND V.	Student in Electrical Engineering Columbia College; residence, 50 E. 31st St., N. Y. City.	F. B. Crocker. G. F. Sever. C. T. Rittenhouse.
DENISON, SYLVESTER P.	143 Centre Street, New York City; residence, Belleville, New Jersey.	Jos. Wetzler. R. W. Pope. Geo. M. Phelps.
FARNSWORTH, ARTHUR J.	Chief Engineer, Larchmont Electric Co., Mamaroneck, New York.	Chas. R. Cross. W. L. Puffer. R. W. Pope.
FISHER, HENRY W.	Electrician and Director of Elec. and Chem. Laboratories; The Standard Underground Cable Co., Pittsburg, Pa.	Wm. Maver, Jr. Harris J. Ryan. Fred'k Bedell.
FRIDENBERG, HENRY LESLIE.	*M. E.*, Student in Electrical Engineering, Columbia College; residence, 60 E. 61st St., N. Y. City.	F. B. Crocker. G. F. Sever. C. T. Rittenhouse
GALLAHER, EDWARD B.	Electrical Engineer, 253 Broadway, room 910; residence, 1190 Madison Ave., N. Y. City.	L. W. Serrell. Jos. Wetzler. T. C. Martin.
KLINCK, J. HENRY.	Graduate Student, Cornell University, Ithaca, N. Y.	Harris J. Ryan. Fred'k Bedell. Ernest Merritt.

LANPHEAR, BURTON S.	Fellow and Graduate Student in Electrical Engineering, Cornell University; residence 106 Union Ave., Ithaca, N. Y.	Fred'k Bedell. Ernest Merritt. Harris J. Ryan.
LESLIE, EDWARD A.	Vice-President and Manager, Manhattan Electric Light Co., L't'd, N. Y. City; residence, 343 Hancock St., Brooklyn, N. Y.	Edw. Caldwell. Ralph W. Pope. Wm. Maver, Jr.
LESTER, WILLIAM B.	Western Union Tel. Co., 195 Broadway; residence, 346 Lenox Ave., New York City.	G. W. Gardanier. James Hamblet. Richard Pfund.
RENNARD, JOHN CLIFFORD, *A. B. E. E.*,	Assistant to Electrical Engineer, Met. Telephone and Tel. Co.; residence 302 W. 73d St., New York City.	John J. Carty. M. I. Pupin. F. B. Crocker.

Total, 13.

TRANSFERRED FROM ASSOCIATE TO FULL MEMBERSHIP.

Approved by Board of Examiners, October 5, 1894.

WRIGHT, PETER	Inspector of Electrical Works, United Gas Improvement Co., Philadelphia, Pa.
ABBOTT, ARTHUR V.	Chief Engineer, Chicago Telephone Co., Chicago, Ill.

Approved by Board of Examiners, December 17, 1894.

MARKS, LOUIS B.	Electrician, Marks-Ayer Electric Co., 73 Watt St., New York City.
BAILLARD, EDWARD V.	Manufacturer of Electrical Instruments, etc., 108 Liberty St., New York City.
BROADNAX, FRANCIS	Engineer, Safety Insulated Wire and Cable Co. New York City.

Total, 5.

Dr. A. Macfarlane then read the following paper "On the Units of Light and Radiation."

A paper presented at the Ninty-third Meeting of the American Institute of Electrical Engineers, New York President Houston in the Chair, and Chicago, January 16th, 1895.

ON THE UNITS OF LIGHT AND RADIATION.

BY A. MACFARLANE, D.SC., LL.D.

One of the recommendations made by the sub-committee of the INSTITUTE in the programme for the International Electrical Congress at Chicago, was that the practical unit of illumination should be defined as the illumination produced by the bougie-decimale at the distance of one metre, and that this unit should be denominated the "bougie-metre." To this definition little objection was made, excepting that Professor Nichols pointed out that it involved an arbitrary standard of light which had no relation to the C. G. S. system of units. More general objection was taken to the notation for the unit.

The London *Electrician* for February 3, 1893, objected to the "bougie-metre," that all other such compound names imply a product of the components, while in this case the former component is divided by the latter, or, more correctly, multiplied by the square of its reciprocal; and suggested, half seriously, that instead of "candle-foot" we ought on the "mho" principle to speak of "candle-toof-toof."

M. Hospitalier made the same objection, that "bougie-metre" according to existing usage means a product, and suggested "bougie-at-a-metre," or, if that were inadmissible the use of a new term such as "lux." M. Blondel favored the single term "lux," and Mr. Lockwood, the single term "davy."

Consider the philosophy of the substitute suggested by the *Electrician*. If we attempt to formulate the "mho" principle, we find that it may be expressed as follows:—The reciprocal of a given unit may be denoted by writing the name for the direct unit backwards. It supposes that the given unit can be expressed

as the ratio of two other units; thus, ohm is the single name for the ratio, volt per ampere. The reciprocal idea is ampere per volt, and there is a convenience in not introducing a new and independent word, but in denoting it instead by the direct term written backwards.

It appears to the writer that here we have a principle which might well be adopted in mathematical analysis, for we have all felt the want of a suitable notation for a function, which is the reciprocal of a given function; for example, the reciprocal of *tan* or *sin*. English and American writers use tan^{-1} and sin^{-1}, a notation which is half word, half symbol; which cannot be pronounced; and which suggests the reciprocal quantity instead of the reciprocal function. Continental writers use "arc tan" and "arc sin," which are too long and periphrastic. On the "mho" principle, the reciprocal of "tan" is "nat" and that of "sin" is "nis." Let $x = \tan y$, then $y = \text{nat}\, x$; let $a = \sin b$, then $b = \text{nis}\, a$. According to Lord Kelvin, who, I believe, introduced the "mho" notation, the expression for a function should consist of three letters; and it may be added, the middle letter ought to be a vowel, the other two consonants. Such a syllable notation when inverted remains a syllable. This notation would have the advantages of being short, unambiguous, articulate and logically connected.

But in the case of a fundamental unit, such as the foot, is there any reciprocal idea? It is true that there are physical quantities which have the dimension l^{-1}; but on examination they will be found to express a physical ratio of some kind. For example the unit of curvature has the dimension l^{-1}; it is expressed by radian per foot. The reciprocal unit is foot per radian, having the dimension l; it is not a measure of length, but of flatness.

The difficulty experienced in expressing the intensity of a candle or other spherical source arises from the want of a name for the unit of solid angle. Just as the natural unit for plane angle is metre of arc per metre of radius, so the natural unit for solid angle is square metre of spherical surface per metre of radius squared. The name "radian" given to the former unit (Everett's "Units and Physical Constants," 1879), has been very useful in expressing exact ideas; a recognized name for the latter unit would also be highly useful. For this purpose the word "steradian" was introduced by Dr. Halsted in his Metrical Geometry in 1880, and I have used it in my work on Physical Arithmetic. Though

not faultless from the point of view of the etymologist, it is sufficiently expressive to the physicist.

How then is the unit of illumination properly expressed? Suppose that by "bougie" is meant the current of light which streams from a uniform standard candle through one "steradian," then the illumination anywhere may be expressed in terms of bougie per square metre, where the former component refers to the current, and the latter to the cross-section. But in the case of light streaming from a uniform point source, the illumination may be expressed in terms of (bougie per steradian)-(steradian per square metre), where the former component refers to the intensity of the source, and the latter to the solid angle subtended at the source by one square metre of cross-section. If "lux" is the single term for this unit, we have

$$\text{lux} = \text{bougie per square metre}$$
$$= (\text{bougie per steradian}) \cdot (\text{steradian per square metre}).$$

Hence, candle per square foot or (candle per steradian)-(steradian per square foot) is the proper expression for the candle-toof-toof of the *Electrician*.

According to the above definition of "bougie," the total current from the candle would be 4π "bougies." But if "bougie" is defined to mean the total current from the candle, and by "lux" is meant the same quantity as before, we should have

$$\text{lux} = \frac{1}{4\pi} \text{ bougie per square metre.}$$

We cannot logically avoid the 4π; exclude it from the source it appears in the intensity, and *vice-versa*. This point is overlooked in the established system of magnetic units, and forms the basis of Heaviside's rational system.

The use of the hyphen to denote a product unit is not very appropriate, for it suggests the sign minus rather than the sign of a product. It would be better if it were omitted altogether, and the two component units amalgamated as in footpound and kilogrammetre; for then the nomenclature would correspond to the algebraic convention which leaves the sign $\times$ to be understood, and in addition the hyphen would be set free to denote any compound unit other than the product or quotient.

If we consider the general subject of radiation we shall be led to distinguish the following ideas with their corresponding units:

TABLE I.

Idea.	c. g. s. Unit.
1. Quantity of radiant energy.....	Erg.
2. Current.....	Erg per sec.
3. Strength of source	Erg per sec.
4. Intensity of spherical source.	Erg per sec. per steradian.
5. Intensity of cylindrical source	Erg per sec. per (cm.-radian).
6. Intensity of plane source.....	Erg per sec per cm^2.
7. Density of source	Erg per sec. per cm^2.
8. Intensity of current.....	Erg per sec. per cm^2.
9. Time flow.....	Erg per cm^3.

Quantity of radiant energy of whatever kind can be expressed in ergs, and a *flow* in ergs per second. By *strength of source* is meant the whole quantity of radiant energy which leaves the source in a given time divided by the time; the appropriate unit is erg per second. The *intensity of a source* is differently expressed, according as the radiation is spherical, cylindrical, or plane. In the first case it is the ratio of a current through a solid angle to the solid angle, and hence it is appropriately measured by the erg per second per steradian. In the second case it is the ratio of a current through a wedge-angle to the wedge-angle. There is no recognized unit of wedge-angle; as it involves the radian in one plane, and a length along the perpendicular to that plane; it may be expressed by cm.-radian. Hence the intensity will be expressed in erg per second per (cm.-radian). If the radiation proceed from an infinite plane, its intensity is measured in terms of erg per second per cm^2.

By the *density* of the radiation at any point of a source, is

TABLE II.

Idea.		Unit.	Symbol.
French.	English.		
1. Quantité de lumière.	Quantity of light.....	Rad.; lumen-hour.	Q
2. Flux lumineux.....	Luminous flux	Lumen	F
4. Intensité lumineuse.	Luminous intensity	Pyr.....	I
7. Radiation intrinsèque	Intrinsic radiation	Lumen per cm^2.. .	R
8. Éclairement.....	Illumination	Lux.....	E
9. Illumination.....	Quantity of illumination	Phot	L
Éclat intrinseque....	Intrinsic brightness....	Pyr per cm^2.....	E

meant the ratio of the flow normal to a small surface, to the small surface, and is expressed in terms of erg per second per cm². By *intensity of current* anywhere, is meant the ratio of the flow through a small cross-section, to the cross section, and it is also expressed in terms of erg per second per cm². By *time flow* is meant the ratio of the energy which has passed through a cross-section, to the cross-section; it is expressed in terms of erg per cm².

The above is the appropriate system of C. G. S. units for any kind of radiation measured simply as energy. But in the case of light, the eye exercises a selective power, not only singling out a certain range of wave-lengths, but discriminating among them as to amount. If one of the units is defined with reference to this discrimination exercised by the eye, then the other units of the light system can be defined in terms of it, and the units of length and time.

Recently M. Blondel has published (*La Lumiére Électrique*, July 7, 1894), an ingenious and logical system of units of light with corresponding practical units. When the ideas are arranged in the same order as in Table I, we obtain the system exhibited in Table II.

By "pyr" is meant a luminous intensity equal to one-twentieth part of the luminous intensity of the Violle standard. By "lumen" is meant the current of light through a steradian, the spherical source having a uniform intensity of one pyr; that is,

$$\text{lumen} = \text{pyr-steradian}.$$

By "lux" is meant the illumination produced by a current of one lumen falling perpendicularly on a surface of one square-metre; hence,

$$\text{lux} = \text{lumen per square metre}.$$

The idea of No. 9 is expressed in French by illumination, but this word in English means éclairement; hence it has been proposed by M. Hospitalier to introduce "lumination" into both the French and the English languages to express the idea in question.

The "phot" is defined as equivalent to "lux-second." By "rad" is meant the unit of quantity of light. It is defined by

$$\text{rad} = \text{lumen-second}$$

just as the coulomb is defined by

$$\text{coulomb} = \text{ampere-second}.$$

The "phot" and the "rad" are said to be of special use in photography. But it may be asked whether the actinic system of units is not independent of the optical system. Is not the "pyr" then defined by the actinic effect instead of the optical effect? If so, we have two complete systems of units, both different from, but parallel to the radiant energy system.

M. Blondel does not introduce Nos. 3 and 5. Let "bougie" denote a spherical source having a uniform intensity of one pyr; then we would have

$$\text{bougie} = 4\,\pi \text{ lumens.}$$

The symbols given in the last column of Table II have been proposed by M. Hospitalier, and he asks for criticisms. In the system of symbols and abbreviations recommended by the Congress, all quantities are denoted by oblique letters or script letters, and units and abbreviations for units by perpendicular letters. The proposed symbols, from their perpendicular character, will not harmonize well with the other symbols of quantity. Also they are already in use to denote vector quantities.

Discussion in New York.

The President:—I will ask Mr. Kennelly if he will kindly open the discussion on this paper.

Mr. A. E. Kennelly:—Mr. President and Gentlemen. I think we are much indebted to Dr. Macfarlane for bringing before us this evening a paper upon a subject of especial and rising importance. The deficiency in the nomenclature and in the measurement of illumination and light, is most noteworthy at the present time, when in electrical science we are developing a very praiseworthy accuracy in symbols, notations and definitions, and this contrast is so great, that it is surely time we were ashamed of the disparity, and were making serious efforts to improve the condition of affairs. The subject has been treated recently in the paper referred to by Dr. Macfarlane, namely that of M. Blondel in "*La Lumière Électrique*" of July 7th of last year, and all those who are interested in the subject can hardly fail to be especially interested in that paper. M. Blondel draws special attention to the great difficulties under which we lie in relation to discussion and expression, owing to the absence of any word or term to express the total quantity of light. It is true that in this Institute efforts have been made, notably upon the occasion mentioned in the first paragraph of the paper before us, when the attention of the Chicago Congress was initially directed to the deplorable deficiency in nomenclature in this direction. But it has been urged that the time was not ripe for maturing any system of nomenclature or of symbols, for the

reason that we had no C. G. S. system of light. It is true that we have no C. G. S. system of light, and that our knowledge is so far behindhand, that we can hardly expect, even in the near future, to have a unit of light based upon the centimetre, gramme and second system. But the position I wish to take is, that we are as fully prepared now to define and name a unit of light as those who represent us may be in the far future, when the knowledge of this subject will be, we trust, much improved. Light never can be expressed in C. G. S. units for the reason that it is merely a physiological quantity. Of course, radiant energy is expressible in ergs, *i. e.*, in C. G. S. units. But so soon as we come to questions of practical importance, when we leave the domains of radiant energy, light necessarily becomes a physiological question, and if we desire to be very precise, we absolutely do not know that any standard sources of light, as we measure it or know it to-day, would have the same magnitude as the same source selected in the times of the Greeks or Assyrians. In other words, we have no evidence sufficient to assure us that the human eye is exactly the same instrument that it has been in previous centuries, or that it will be in centuries to come; and consequently it is impossible to define light practically, industrially, commercially, by any C. G. S. system of units. It is true that we may call so many ergs expended in such and such a wave length of such and such a frequency, as representing the unit quantity of light. But until we are supplied with sources of light which are entirely monochromatic, so surely must we mingle different wave lengths and frequencies; and then the difficulty comes as to how we shall compare different colors, and the only way in which that difficulty can be met is by the use of the eye, and the physiological factor enters into it. I trust, therefore, that the members will agree with me, that the time is now ripe for the adoption of some term covering and conveying the idea of "quantity of light." M. Blondel suggests the term "lumen." Call the unit what you please, it is of great importance. We are constantly making mistakes in our own thoughts, even those who are giving the subject close attention, and who are supposed to be conversant with its practical and technical details, while those who cannot and do not give the subject the attention it merits, are continually falling into pitfalls, on account of the absence of a phrase expressing quantity of light, and the absence of the series of ideas it would convey. Suppose we adopted such a term as "lumen," I think that the question as to how far the use of that term might become invalidated by subsequent improvements in photometry, would be eliminated in the way that questions concerning the magnitude of the ohm were eliminated. Electricians did not refrain from producing the ohm in 1861 because their methods were not sufficiently accurate. They produced the ohm to the best of their knowledge, capabilities and beliefs, and the ohm was correct within about one per cent., and subsequent at-

tempts have improved upon the valuation then arrived at. So in the same way, if our methods of measurement of to-day are notably inferior to what they should be for a precise definition of a standard of light, some such term as "lumen" can be adopted as representing a specific quantity, and in future such measurements as may be made more correctly, and by processes more accurate than at present, can correct that quantity and render it with all the precision of the science that is to come. It is a matter of great difficulty for any men, or even for any institution, to move independently in a direction of this kind at the close of the nineteenth century, and I think we could not do better than call upon our colleagues, call upon allied societies in other parts of the world, requesting the expression of their opinion upon the subject as to whether the "lumen" is a good name, whether the "lumen" itself is a good unit, and whether any concerted expression of opinion can be arrived at on this point. The position I desire to take is that we are ready now, if we can only get concerted action, to adopt a unit which may be practically, industrially and commercially employed. I think it is eminently desirable that we should exclude the names of persons from such a system of units, and I think that M. Blondel's position in that respect, so far as he has shown it in Table II., is a correct one. It is to be noted that the unit of illumination that M. Blondel has taken, and which Dr. Macfarlane here represents, is that unit of illumination proposed by this INSTITUTE for the consideration of the Chicago Congress, namely the "bougie metre," the bougie being the bougie decimale or the one-twentieth part of the Violle standard. That produces an illumination which is the "lux" here suggested, namely the "lumen per steradian". That unit has therefore been long proposed, and it has already a name suggested for it. Mr. Preece about ten years ago suggested the name "lux," for the carcel-metre. The carcel-metre happened to be about the value of a candle-foot. In other words, the British candle gave at about the distance of a foot, the same illumination that the carcel lamp gave at the distance of one metre. Since that time, the carcel lamp has ceased to be a generally recognized standard outside of France, its place having been taken by the Violle, standardized by the Paris Convention of 1889, and the bougie decimale, nominally one-twentieth part of the Violle is the recognized standard of luminous intensity to-day, although many secondary standards are in daily use; such, for instance, as the Hefner-Alteneck, the British candle and the new Reichsanstalt standard. There is one unfortunate fact concerning all the units that are suggested by M. Blondel, and that is that they are not all centimetre units, some are metre units. If you glance through Table II., it is evident that the metre enters as the standard of reference. That is an unfortunate fact which, perhaps, cannot be averted at the present time, for the reason that the "phot" having been already adopted by the International Congress of Photographers at

Brussels in 1892; it is, perhaps, too late to select a centimetre unit for that purpose, and since the "bougie-metre," which corresponds to the "lux," has also been adopted practically, the system cannot be altered to suit the centimetre standard of length; the metre must run through it. The symbols, however, are unfortunate. The block symbols, in Table II. proposed by M. Hospitalier, as stated by Dr. Macfarlane, are already in very general use as denoting vector quantities, and some of these units are not vector quantities. It is therefore desirable, that a special notation should be employed which does not conflict with the vector notation, and it would be possible to put an asterisk or star, or some sign of notation attached to the ordinary capital letter to indicate that the unit of light was intended.

I hope, therefore, that the members will be in accordance with me that some action should be taken in this matter to endeavor to obtain a system of units for light and illumination, in which at least the unit quantity of light should be clearly understood.

THE PRESIDENT:—Gentlemen, you have heard the remarks of Mr. Kennelly. Do you wish to take up his suggestion now or will you discuss the paper first? I understand Mr. Kennelly to suggest that the INSTITUTE call on societies in different parts of the world to ascertain whether or not they have any suggestion to make concerning the use of the word "lumen" as a unit of flux or quantity of light. Should you see fit to do this it would seem to me that our regular Committee on Units and Standards would be a good committee to refer that to. However, it is for you to determine.

MR. TOWNSEND WOLCOTT:—I wish to make a few remarks only, about a portion of this paper which refers to what you might call "mho" units. There is worked out here a system which is entirely consistent with itself. But it seems to involve the same difficulty as the other notation. If we write $\tan^{-1}$, the difficulty seems to be that people mistake this inverse function for the reciprocal of the tangent. The only word of the kind proposed we have adopted so far is "mho," which is ohm spelled backward, which is reciprocal rather than the inverse function. It seems to me there would be danger that people would confound it in the same way. As to the expression, $\tan^{-1}$, it seems to be perfectly logical, only the principle is not carried out. The old English writers on mathematics, De Morgan—in fact everybody so far as I know that has written on calculus operations, otherwise called the functional calculus, used that notation for all functions. If we write φx; φ represents an operation, and then if we put an index to it, for instance ^{2}, that means the operation is repeated. If we put $^{-1}$, it would mean that that operation is performed the other way—an inverse operation is performed. The only trouble is when we go further. Most people when they write, $\tan^2 x$, mean the tangent of x^2, as Professor Macfarlane says. It might be perhaps well to have Professor

Macfarlane's notation in addition to that. We sometimes have two notations for the same thing, and it does not do any harm. For instance, besides fractional indices such as $x^{\frac{1}{2}}$, we also write that expression the other way: $\sqrt{x}$. If we put $\frac{1}{x}$ there: $\frac{1}{x}\sqrt{x}$ it would be just the same as x^2. We have two ways of writing the some thing.

This word "toof," instead of foot, is suggested to represent the reciprocal of a unit rather than an inverse operation, while Professor Macfarlane's reversed words represent operations performed—inverse operations instead of the reciprocals. It seems that there is just the same danger of people getting those two things mixed up as there is in the present notation.

THE PRESIDENT:—Is there any further discussion on this paper? Do I understand that there is a motion before the INSTITUTE respecting the suggestion that this matter be referred to the Committee on Units and Standards?

MR. WOLCOTT:—I move that the subject be referred to the Committee on Units and Standards.

THE PRESIDENT:—It is moved that the subject be referred to the Committee on Units and Standards, with the view of communicating with institutions in different parts of the world in order to ascertain their views as to the fitness for that use of the word "lumen" for quantity of light.

[The motion was carried.]

MR. DOUGLASS BURNETT:—Prof. Macfarlane is to be congratulated in adding to the results so carefully and searchingly obtained by Mons. A. Blondel. M. Blondel has emphasized for us the idea of flux of illumination. A perusal of the articles which have from time to time appeared on the subject of the distribution of illumination, shows the general application of the term "quantity of light," to the expression of this idea, with the omission of the term "radiated per unit time."

In considerations like the present, we must distinguish between units for practical, and for theoretical application. Practically we are concerned simply with (*a*) the intensity of the source of light, and (*b*) the brilliancy of illumination of the exposed surface. Theoretically we must have in mind the operations in progress in the space between the source and the illuminated surface.

In considering the radiation of heat from cooling bodies, which, being at high temperatures, are sources of energy, or the radiation from hot bodies in which the heat is continuously supplied, we arrive without difficulty at the idea of a flux of energy from such bodies; and we ordinarily speak of the number of calories or B. T. U. radiated per unit time through a certain space from a surface of unit area. In the case of the conduction of heat within a solid medium, the same terms may be used.

Then by the use of the mechanical equivalent of heat, these numbers are transmuted to energy units—kgms. or joules In light however, it is not ordinarily so evident that there is a radiation of energy from a luminous body, or a reflection of energy from reflecting bodies, and in consequence we use in photometry the candle as the unit of intensity of a source, or the candle foot, or foot candle, as the unit of light received on a surface. The idea that in the space surrounding a source of light, there is a continuous passage in straight lines in all directions of that which may be transformed into mechanical work, is not usually apparent in such considerations.

As it stands, M. Blondel's paper is not complete, in that it fails to include the ideas which Dr. Macfarlane has summarized in Table I. The idea of the distribution of energy in the space surrounding a luminous source lies at the root of this table.

It is to be hoped that at no very distant date illumination will be capable of being expressed in absolute units. We note with pleasure Prof. R. A. Fessenden's suggestion on page 108 of the 1894 issue of our TRANSACTIONS, with reference to the visual effects produced in various parts of the spectrum, when the radiation of each wave length is regulated in amount to equal one watt; also the results obtained by Prof. H. F. Weber, given to the Berlin Academy of Sciences in 1888, which included a formula expressing the relation between the intensity and any selected homogeneous radiation, the corresponding wave length, the temperature and the quality of the radiating substance.

It seems quite possible that with certain data supplied, we could at present express in energy units any amount of light which may pass through a given space. This it seems might be done by combining the efficiency of the source (the ratio of luminous to total radiation) with the total energy supplied. Thus in the case of sunlight at the earth's surface: Werner Siemens has given its luminous efficiency as 25 per cent. Langley has measured the radiation received from the sun at zenith to be 133 foot-pounds per square foot per second; also Young has given the zenith illumination as 60,000 metre candles. We have here by reduction 44.76 watts of light received per square foot, or 482 watts per square metre, in the form of light. That is, there is a flux through a square cm. of cross-section of the ray of light equal to 482×10^3 ergs per second.

Similarly we might express the light energy radiated from a 50-watt 16-candle incandescent lamp with 5 per cent. luminous efficiency (Merritt). We may thus find that in order to secure the same intensity of illumination as is produced by the sun, as above supposed, the filament should be placed at the center of a sphere of 2 cm. radius. In that case, light energy would be received at a density of 482 watts per square metre on the inner surface of the sphere.

The light produced by a gas flame might similarly be estimated in absolute units, by taking into account the calorific power of

the fuel, its rate of burning, the mechanical equivalent of heat, and the luminous efficiency of the flame, which is approximately 5 per cent.

Considering further an arc with 10 per cent. luminous efficiency (Nakano) we may determine the amount of energy in watts or joules per second, radiated as light from this source.

Having once obtained the radiation from a source in absolute units for several typical cases, photometry as ordinarily carried out will give the value of the energy of any measurable source. Thence we may obtain measures for each of the items enumerated in Professor Macfarlane's Table I.

II.

The English unit in common use corresponding to the pyr, is the candle. We have the definition—

lumen = pyr-steradian.

The "lumen" is similar to a candle-steradian. We have in the English system, however, no unit similar to the "lumen." If we attempt to express the idea embodied in this name we will find that our sole means of expression is the foot-candle per square foot; this, however, is not an appropriate name, inasmuch as the light of one foot-candle shining upon two square feet, is equal simply to one foot-candle *over* two square feet. While the amount of radiation equals theoretically two foot-candles per square foot, yet this statement would not be applicable to the case of the concentration of light produced by a projector, for the term may only refer to the intensity over each square foot. The illumination in the above case is not two, but one foot-candle per square foot. The statement can only be made definite by the use of some such term as candle-steradian.

III.

The word "ray" is capable of an exact mathematical definition just as is the magnetic term "line of force." The latter represents unit intensity of magnetization; the former may represent unit flux of light, or intensity of radiation passing through unit cross-section. A light of certain candle power may be stated as emitting a certain number of rays per square cm. at unit distance, as a magnetic field may be said to be traversed by a definite number of lines per square cm. The parallel beam from a projector might be referred to as being of density so and so many rays per square inch or centimetre.

IV.

While on the subject, we might take it upon ourselves to point out that the space candle-power curve as ordinarily found in papers expressing the results of photometric measurements, does not carry the idea which it is intended should be given. In case

of a vertical candle power curve of an arc lamp, if the intensity under various angles with the horizon, be reduced by means of the formula: Intensity of illumination (foot-candles) = intensity (candles) at source ÷ (distance)^2, we may get vertical curves showing the actual illumination produced at the various points in the space surrounding the arc lamp. Such curves drawn through points of equal illumination may be called "isophotals."

If a map of such curves be made, the curve referring to values of 1, 2 . . . . . etc., foot-candles, and a line representing an illuminated surface in section, be drawn to cut such curves at a definite distance from the lamp, the amount of light to which these curves individually refer will be incident upon the points at which they cut the lines so drawn; and therefrom may be drawn, if so desired, another curve, representing these various values of illumination as we proceed from point to point of said surface.

In conclusion, I may state my belief that the expression of such ideas as are found in both Dr. Macfarlane's and M. Blondel's paper cannot fail to be of inestimable value in the clarification of photometric conceptions.

[Communication Received After Adjournment.]

Mr. Clayton H. Sharp (*communicated*):—In regard to what Dr. Macfarlane says concerning the name of functions which are reciprocals of already named functions or units, it seems to me that we must not lose sight of the fact that words are essentially *sounds*, which among civilized people are represented by a certain combination of symbols. In forming a word by inverting the order of the letters of a known word, we reverse the historical and logical process of word formation and violate all etymological principles. If we wish to express the fact that a relation exists between a unit and its reciprocal, we should give to the reciprocal a name, *i. e.*, a sound, that will suggest the relationship. For example, the symbol "sin." stands for a particular word. We can, according to phonetic laws, give to the symbol "nis." a sound; but this word will bear no relationship to the word represented by "sin." The word which we might imagine to be represented by a "candle-toof-toof" is just as good English as it is Choctaw, and no better. Moreover, the appearance of a word, formed by inversion, conveys no idea to the brain unless we cultivate the Chinese art of reading backward. That this so-called "principle" has its limitations is evident, if we suppose that we wish to form, according to it, a name for the reciprocal of the "watt."

The table of c. g. s. units of radiation which the author gives is very interesting. The only thing lacking is a method of establishing a c. g. s. unit of luminous intensity, and unfortunately, we seem to be about as far from that as ever. The units pro-

posed by M. Blondel are undoubtedly logical, and their names are well chosen. The chief objection to them outside of that urged by Dr. Macfarlane is, it seems to me, that we have little or no use for them. We do need a name for the unit of luminous intensity, and, perhaps a simple, rather than a compound name for the unit of illumination would be desirable. Further than this in the naming of units, it seems to me that we need not go. The other units are used so little that it would not be burdensome to employ compound names for them, and it is always to be remembered that a multiplicity of abstract names invariably causes confusion.

Mr. Alton D. Adams read the following paper on "The Best Metal for Field Magnet Frames."

A paper presented at the Ninety-third Meeting of the American Institute of Electrical Engineers, New York, President Houston in the Chair, and Chicago, January 16th, 1895.

THE BEST METAL FOR FIELD MAGNET FRAMES.

BY ALTON D. ADAMS.

Cast-iron, cast-steel and wrought-iron being the materials at our command for field magnet construction, it is an important question to the engineer and manufacturer, which will produce a dynamo of given capacity, speed, efficiency and working qualities at the least cost.

I am not aware that any of the works on dynamo construction attempt a definite answer to this question, and the practice of builders is by no means uniform. Economical points of saturation requiring about the same magnetizing force per unit of length in each metal, are for cast-iron a little under 40,000, cast-steel, 70,000 to 80,000, and wrought-iron about 90,000 lines per square inch.

The cost of cast-steel is fully equal to that of forgings in simple shapes, and as it lies between cast and wrought-iron in magnetic qualities, the cost of machines made with it will be between those of cast and wrought-iron. A comparison will, therefore, be made between the cost of the latter two.

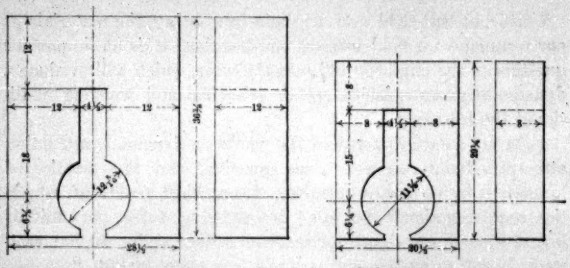
To be fairly compared, machines of different materials must be equal as to magnetic flux in field and armature cores, ampere-turns on armatures, field ampere-turns required in air-gaps, and as nearly as possible in magnet frames, watts used in windings, and be of the same capacities and speeds.

Taking wrought-iron at a saturation of 90,000 and cast at 40,000 lines per square inch, the section of an equivalent cast, will be two and one-quarter times that of a wrought frame, and as the length of the cast-iron frame must be a little greater to give enough winding length, its weight will be about two and one-half times the wrought. A saving is thus at once made in

favor of the wrought magnet, as forgings can be had per pound for much less than two and one-half times the cost of cast-iron.

The same number of ampere-turns and watts being required for the coils of the cast as the wrought-iron magnet, and the weight of wire varying as the square of its length, the coils for the cast-iron frame will be much heavier. The armature core may have the same diameter in each frame, but must be longer in the cast frame so as to come under the pole-pieces, thus materially increasing its weight.

As for the same resistance, the weight of armature winding increases as the square of its length, considerably more wire is required for the armature core of the cast-iron machine. In addition, the purely mechanical parts, shaft and base must be larger



and more costly in the cast-iron machine because of the greater weights they have to carry.

To illustrate the difference in cost of construction, the following data of two machines is presented, each having capacity of 25 K. W. of 1,275 revolutions per minute, the same winding losses, the same ampere-turns on armatures and field ampere-turns in air-gaps equal to about twice the armature ampere-turns active at the pole corners.

The air-gaps and armature cores of each machine are crossed by 4,320,000 magnetic lines, and allowing a leakage of 25 per cent. the field core must furnish 5,760,000 lines.

A wrought-iron field to carry 5,760,000 lines, at 90,000 per inch saturation, requires a section of 64 square inches, which is provided by a core of 8 inches square and a cast-iron field at 40,000 lines per square inch requires a section of 144 square inches provided by a core 12 inches square.

Allowing sufficient length for magnet windings, the same air-gap resistance and an armature core of 11 inches diameter for each of these frames, their dimensions will correspond to the above drawings.

The weights of these frames are

Wrought-iron frame	1020 lbs.
Cast-iron frame	2730 "

For work as shunt motors the wrought-iron machine requires 11,000 ampere-turns in the air-gaps and 2,000 in iron, the cast machine 11,000 ampere-turns in air-gaps and 3,800 in iron.

With 440 watts expended in field coils of each machine, an average length per turn of 38 inches in the coils for wrought-iron, and 54 inches in the coils for cast-iron, the weights of these coils are

Wrought-iron machine	133 lbs. copper.
Cast-iron machine	340 " "

The drum armature for the wrought frame is 11 inches diameter and 8 inches long, that for the cast frame 11 inches diameter and 12 inches long, without allowance for shaft hole.

The weights for armatures are

Wrought-iron machine	211 lbs. disks.
Cast-iron machine	316 " "

With a loss at full load of 490 watts in the armature winding for wrought-iron machine, and 464 watts in the armature winding for cast-iron machine, these windings require in

Wrought-iron machine	49 lbs copper.
Cast-iron machine	71 " "

The above indicates plainly the great saving of wrought over cast-iron in dynamo construction.

From the users' standpoint the wrought-iron machine seems preferable on account of its lesser weight and bulk, this difference being especially marked in machines for direct connection to engines, and other purposes where slow speed is necessary.

Discussion.

The President:—I will ask Prof. Crocker if he will open the discussion on this subject.

Prof. Francis B. Crocker:—Mr. President and gentlemen, I regret that Mr. Adams did not carry this subject further, because it is certainly interesting, and is also very important. The principal comment would be in regard to treating the subject more fully. But I note one or two points. In the first place, he dis-

poses of cast-steel in a manner which I think is hardly worthy of it. I mean to say that I think it deserves better treatment; because, in the first place, the cost of cast-steel is less at present market prices than that of forgings of the same shape. For example, cast-steel can be obtained in ordinary sizes and shapes, and in quite complicated shapes at four cents per pound. Drop forgings would probably cost something like six or seven for similar shapes and similar sizes. To be sure we can get plain wrought-iron in bar shape, for example, or cylinders of wrought-iron, for two or three cents a pound; but before these were gotten into shape to be used for dynamos and motors they would cost considerably more, on account of the machine work, and the fitting on of the pole-pieces and various parts. The raw material might be fairly cheap, but before it was gotten into the finished shape, I think it would cost more than the cast-steel, to say nothing of the complication and disadvantage of having a machine made up of several parts instead of one integral casting. Consequently, I should say that cast-steel should be put ahead of wrought-iron as a material for the field-magnets of dynamos and motors.

I would also like to call attention to the fact that the terms "cast-steel" and "wrought-iron" are arbitrary. We are accustomed to consider wrought-iron as a certain material, and cast-steel as quite a different material, but those names are based usually on the processes of production, and not on the chemical composition or physical properties of the metal obtained. I do not think that point is fully realized by those who have not made a special study of it. Mr. Tesla called my attention to the fact several years ago that "steel" may be actually purer iron than the ordinary wrought-iron of commerce. Consequently it is really cast wrought-iron, and therefore we might expect, and we do actually get about the same magnetic permeability for cast-steel as for wrought iron, simply because it is nearly pure iron in both cases, the impurities being about the same. Of course very pure wrought-iron is purer than so-called cast-steel, but ordinary wrought-iron is not. The old idea was, that steel consisted of iron containing about one per cent. of carbon. Of course, to-day, that is not necessarily so, because it is possible to get mild steel which contains only a very small fraction of one per cent. of carbon. The advantage of cast-steel is that it can be obtained in almost any desired shape. I will cite only one case to illustrate where cast-steel could be employed, and is employed very successfully, where it would be out of the question to employ wrought-iron, and that is in the box type of railway motor. It is almost inconceivable that such a machine could be made with a wrought-iron field magnet; whereas cast-steel answers admirably, and boxes with sides only half an inch or so in thickness, can be made very successfully and are just exactly what are required. Less complicated shapes than that might be made in wrought-iron, but usually they can be made much more easily in cast-steel, and even the ordi-

nary magnets with pole-pieces suitable to form the field space can be made in cast-steel more easily than they can in wrought-iron. Consequently it seems to me that cast-steel is really the thing to compare with cast-iron as a material for field magnets. It is rather convenient that if we make a square, or circle, or other similar figure of one and one-half times the linear dimensions we get an area two and a quarter times as great. Consequently this ratio is exactly right to make up for the relative permeabilities of cast and wrought-iron, and in designing and comparing dynamos and motors, this is rather a convenient point. It is contained in this paper, but it is so simple that it is worthy of special notice.

A point that Mr. Adams does not touch upon is the making of composite machines. By that, I mean a machine, for example, with wrought-iron or cast-steel magnet cores and with cast-iron yokes or base. In many cases that is a great advantage. It is a great advantage because you want the weight in certain places, and the comparison he makes, where cast-iron is so much greater in weight than wrought-iron, becomes converted from a disadvantage to an advantage. In my opinion, and I advocated it before this INSTITUTE some years ago,[1] a certain weight in a stationary machine, particularly if that weight is placed near the ground, is positively desirable, and a cast-steel frame throughout, in my opinion, would not make as desirable a machine as one with a certain amount of cast-iron put in the base as ballast, so to speak. That involves machine work and complications, which I said was somewhat objectionable; but in most cases it is unavoidable. No one is likely to make the entire machine, including bearings, base and field-magnets, in one piece, and if we are going to make them of two pieces, it is just as well to construct the magnet proper of a material having the highest permeability; and the base, yoke, bearings and other parts, where permeability is not of much consequence, can be made of cast-iron with advantage.

Now there are certain peculiar designs of machine, where a certain one of these three materials may be almost essential or desirable, and it will be well, I think, if a somewhat more practical and real case were given than that illustrated in the figures. The form represented here is simply an ideal or abstract magnet, and the rest of the machine is not shown, and when you come to design the entire machine, it might seriously modify the mere geometrical facts that the magnet shown would indicate, and as an illustration, if for no other reason, I think it would be well if the paper were supplemented by the actual design of three or four practical machines. Then I think you would find that the case is not quite so simple as it appears to be in the paper. I presume Mr. Adams' intention was only to give a general comparison, and not special cases, but it would certainly add to the

1. TRANSACTIONS, vol. viii., p. 188.

value of the paper if at least one special case were considered and carried out.

MR. RICHARD FLEMING:—The casual reader of Mr. Adams' paper would be likely to get the impression that there was no other metal than cast and wrought-iron available for dynamo construction. It is not a discussion of the "best metal" for the purpose, as much as it is a comparison of the relative advantages of wrought and cast-iron. Dynamo builders long ago found that wrought-iron was far superior to cast in point of cost and construction, but this is about the only advantage it has over cast-iron, for a dynamo or motor of cast-iron will work equally as well as any wrought-iron machine if the same laws are followed out in the design.

It will be heavier, of course, but that is only a matter of freight and cartage. After it is set up, it matters little to the user whether it weighs one ton or two, if it does its work as well. The extra weight in this case is an advantage, for the machine will be less liable to vibrate on a light foundation.

I do not agree with the author that the armature must be longer in a cast frame. I do not see why any extra length should be allowed so as to come under the pole-pieces. There is no difficulty in designing a machine to have an air-gap area at least equal that of a cast-iron field core with an induction of 40,000 to the square inch. And as 40,000 lines to the square inch in the air-gap is very high, the armature will of necessity have to be made long enough to reduce the induction in the air-gaps to a practicable limit. About 20,000 (square inch) is the average induction in the air-gap. This certainly will not saturate the pole face, and as a wrought-iron frame admits of no higher induction in the gap, there is no reason why the armature should be shorter in the wrought frames.

Going back to the question of the best metal for magnet frames, and allowing that the cost of production of the finished article is the only consideration that governs the choice, there is no doubt in my mind that cast-steel is far cheaper than either wrought or cast-iron. I have not jumped at the conclusion either.

I have made a large number of designs of machines allowing the same efficiency, speed, etc., and found from an impartial consideration of the matter that steel gave the best results. This is due more to the facility with which it lends itself to be moulded into any desired shape, than to any inherent quality as a magnetic material, though between the best wrought-iron and the *best* cast-steel there is little difference in this respect, and the price per pound will be in favor of the steel. The weight of metal in either case for frames of the same capacity will be about the same. The chief advantage of steel will be the small cost of machining, and the shorter time it takes to put it through the shops. This is due to the fact that a frame can be designed so

that when it comes from the foundry there is very little tooling to be done on it, which is a very large item in these days of sharp competition. The finished machine, too, can be made to look better at less cost, and its working qualities will be as good, if not better.

DR. SAMUEL SHELDON:—It seems that data of the magnetization curves of wrought-iron are few. Some one, I think, perhaps, it was Mr. Steinmetz, uttered a suspicion that Hopkinson's iron was remarkably good. Hopkinson's results crop up in all our papers on magnetic phenomena. I have tested a number of samples of cast-steel from different iron firms and I find that you can get a very good quality of open-hearth steel for four cents a pound. We have quite a number of tests on steel, made at Cornell. I have found three samples of steel which lie higher and show a better permeability than the samples of steel mentioned in the Cornell paper. I have found one sample of steel which runs at one portion of the curve—to be sure, it is at a rather high magnetizing force (H = thirty-five)—above Hopkinson's curve for soft iron. Some of the forms of steel do not run as high; for a magnetization of, say, 15 to 25, they run from 11,000 to 12,000. Other samples are from 14,000 to 15,000 for those same magnetizations. So it seems that when we come to consider the ease of manufacture and other points in favor of cast-steel, we certainly cannot throw up the lack of magnetic properties in the face of them.

I should like to know if there are any other members present who have made measurements on wrought-iron which yield inductions as high as Hopkinson's iron.

MR. KENNELLY:—In relation to the question of the permeability or reluctivity of wrought-iron and steel, I never have seen any numerical values obtained by Dr. Hopkinson. I think that Dr. Hopkinson's values, as noted in various papers, are taken from a curve given in his original paper, and I have seen it stated in some of the quotations that they were taken from that curve. In fact, there was an ascending and a descending curve which differed materially. I have made a number of measurements of the reluctivity or permeability of samples of wrought-iron and cast-steel, and have never found any sample of wrought-iron superior, or even equal to the quoted values of Hopkinson's iron in the earlier parts of the curve, that is to say, between three gilberts and ten gilberts per centimetre; but from ten onwards, the samples that I have tested have shown a permeability almost exactly equal to that of Hopkinson's, and some samples of steel that I have tested have been superior to the iron of Hopkinson by a small amount in the same way that Dr. Sheldon describes. While, however, the reluctivity of good wrought iron is very fairly uniform in different samples, the reluctivity of different samples of cast-steel frequently differs materially.

MR. GANO S. DUNN:—I think one reason, perhaps, why such

good curves have been obtained of wrought-iron is because most of the tests that have been made have been made on very small samples, on wires of a few millimetres in diameter, and I believe that such wires would be found to be of higher magnetic quality than a large bar, which is what we have to deal with in the actual construction of the machine. My experience with wrought-iron has been that it has never come equal to Hopkinson's curve, and it frequently falls nearly ten per cent. below it throughout.

Mr. James Burke:—I note that Mr Adams has compared these machines on the basis of the same total watts lost in the magnet coils. It seems to me that one point which might be considered, is a comparison on the basis of the same heating of the coils, for in the case referred to, on account of the very much greater radiating surface in the cast iron machine, its windings would run very much cooler The weight of copper in the magnet windings of the cast-iron machine would be reduced considerably if the same increase in temperature as in the wrought-iron machine is allowed. The actual loss in the magnet winding would be increased on account of this reduction in copper, but as the armature core loss, in the machines Mr. Adams has compared, is much less in the cast-iron machine, for it has a lower density in the core, the efficiency of the machine would not be affected materially.

Mr. Adams points out that the armature has to be very much longer in the cast-iron machine. If the common practice of having a gap density in the neighborhood of 40 to 60,000 is followed, it would seem unnecessary to have a longer armature in the cast-iron than in the wrought-iron machine.

It is sometimes a great advantage in machines with toothed armatures, to use laminated pole-pieces In cases of this kind the cost of construction can often be reduced by using a yoke of cast-iron and casting the pole-pieces into it.

Another condition, wherein cast-iron has some advantages as to cost of material, exists in the magnet yokes of large machines with many poles, in which the section necessary for mechanical reasons is also sufficient to allow a normal density for cast-iron.

I also wish to call attention to the densities that Mr. Adams states for cast-steel, as it is not unusual practice in steel magnet cores to run the density up to 90 or even 100 000.

Mr. W. L. Bliss:—It seems to me that the greatest advantage to be gained from the use of wrought-iron and steel in the manufacture of field magnets for electrical machinery, would lie principally in the construction of small machines. We are almost invariably confined to the bipolar type of magnet in dynamos and motors of small output, and this type of magnet must necessarily be constructed of material of high permeability. In a small machine, the relations existing between the various dimensions are totally different from those of machines of larger output. For instance,

in a small dynamo, the air-gap being enormously larger, simply for mechanical reasons, than is required to secure regulation and sparkless running, a very excessive magnetizing force is required on the fields, and this in turn necessitates the use of a high grade of wrought-iron or steel. When we come to build a larger machine—Mr. Adams speaks here of 25 K.W.—it is a question whether we continue in the bipolar type, or what seems preferable to me, pass to multipolar construction. If we adopt the latter, I think we shall find that after calculating the armature dimensions according to the best modern practice, and allowing sufficient air-gap to secure satisfactory operation, the cross-section of our field magnet and poles will be great enough to admit of the use of almost any metal whether it be wrought-iron, cast-iron or steel. The length of the magnetic circuit in a multipolar machine is always smaller relatively to the other dimensions than in a bipolar, and hence the portion of the magnetic circuit that will require the most attention will be the air-gap. This latter will consume such a large percentage of our magnetizing force, that it matters little what slight reluctances be introduced into the magnetic circuit, and indeed if we employ a construction like that mentioned by Mr. Burke where laminated pole-pieces are cast into cast-iron frames, although such a construction introduces a reluctance at the joint, we need not allow this matter to trouble us, since the ampere-turns required for the air-gap constitute so large a percentage of the total field excitation. Consequently in large machines we are not compelled, either on account of efficiency or first cost, to introduce expensive forgings or even steel castings. It will simply be a question of weight. By using the metals of high permeability we can somewhat reduce weight and bulk. In large machines the air-gap has to be so abnormally increased, beyond that required for simply mechanical purposes, and especially in multipolar forms, that in almost any well designed machine with a toothed armature, it would be possible to take all the conductors out of the slots and distribute them around the circumference of the armature, and still leave plenty of room for banding and clearance. So the question of using steel, wrought-iron or cast-iron, for our field magnets would depend principally on the size of the machine. I think one criticism that could be made on the form of machine depicted in these drawings is that it is perhaps a little antiquated. It does not seem to me a very economical design of field magnet for that output.

PROF. CROCKER:—It seems to me that cast-steel is not the expensive metal that the last speaker implied. Cast-steel can be obtained for four cents per pound, and it is equivalent to fully twice the cross-section of cast-iron. Now, we cannot get cast-iron for less than two cents per pound. Consequently, we are exactly as well off with cast-iron or with cast-steel, so far as the mere cost of the magnet is concerned. And furthermore, to get the same number of ampere-turns with cast-iron it requires about 41 per cent.

more wire than on cast-steel. I, therefore, fail to see that the use of cast-steel is an expensive luxury It seems to me that it is truly the cheapest material for the purpose to-day. We not only get the advantage of the high permeability, but also secure actual economy in wire, and a smaller and better machine in every way.[1]

MR. ADAMS:—I need hardly say that this little paper was not intended to be exhaustive, or to say all that might be said on the subject.

I have often heard ideas expressed similar to those advanced by one speaker to-night, to the effect that cast-steel or wrought-iron makes an expensive, efficient machine, and cast-iron a cheap but rather inefficient machine, and that idea is one which this paper was intended, if possible, to set aside, as I believe that for a given efficiency, speed, capacity and condition of working qualities a high permeability metal, as wrought-iron or cast-steel will make a cheaper machine, cheaper as to the cost of the frame, cheaper as to the cost of the field wire, and cheaper as to the cost of the armature wire than will a low permeability metal like cast-iron. Any way that I can figure it brings out that result.

I will say with reference to the remark of Professor Crocker, concering the relative cost of cast-steel and wrought-iron, that our difference of opinion on that lies largely in the fact that I must have found a cheaper place to buy wrought-iron than he has. As I said in the paper, in simple shapes, such as are required and used for bipolar machines by many parties, wrought iron forgings can be had at as low price per pound as cast-steel. I have never been able to get steel castings that would come within $\frac{1}{16}''$ of the dimensions given on the drawing to the pattern-makers. But one can get rough machined forgings within $\frac{1}{16}''$, and that is, perhaps, not too much leeway to allow in field spools to slip over the cores, and it saves machining in the shop. That I consider a very considerable advantage, as if field spools are desired to fit accurately over cast-steel cores, you must machine the cores in any steel that I have been able to get hold of. Of course, my experience does not cover many makes, and there may be steel castings that come to within $\frac{1}{16}''$ of given dimensions.

With regard to the type of machine taken here as an illustration, I must disagree with some of the remarks that have been made, because I have certainly taken here, if I understand the matter, a type of machine which is made by more prominent manufacturing concerns than any other in the world—the ordinary bipolar, straight, upright, downright field-magnet I do

1. In the paper already cited (TRANSACTIONS, vol. viii., p. 190) I stated that "The supposition that cast-iron is cheaper than wrought is a fallacy, as its permeability is as much below that of wrought-iron as is its price, both being about one-half." The same is now true of cast-steel, which at that time (May, 1891), however, cost about twice as much as at present, and was rarely used for the purpose.

not know of any single type that is made by prominent concerns the world over as generally as that. I fail to see anything ideal, as opposed to practical in this design.

In the wrought-iron design, I have made quite a number of machines running up into the dozens, of about that same section and weight of magnet and same capacity, and from the knowledge that I have of the practice of other concerns in this country and in Europe, I am very certain that a great many machines have been designed and are operated to-day that correspond very nearly as to wrought iron field-magnet with that I have shown. I have also, I am sorry to say, seen some field magnets made by prominent concerns that correspond very closely to the large cast-iron one.

The criticism has been made that the armature should not have been lengthened out for the cast-iron frame. If any gentleman can show how he will shape that frame to get the magnetism from it to the armature core without making that armature core bigger, then the criticism will rest on a solid foundation. I confess I do not know how to do it in a satisfactory manner. It might be done by flattening out the frame and making it only 8″ wide, and then it would have to be big enough the other way to give the section of 144 square inches, which it strikes me would make at least an odd shape of field magnet.

With reference to the magnetic qualities of wrought-iron I may say that in building several hundred machines of wrought iron I have in almost every instance, where I have had well hammered forgings, which are of course essential, been able to get results indicated by Hopkinson's data. My experience with cast-steel, while I have not used nearly as much of it as many gentlemen who have spoken here to-night, has been, that one cannot rely on getting as high permeability with it as in well hammered forgings. It may be, of course, that my experience with cast-steel has been unfortunate, but I have found it rather an uncertain metal in the matter of permeability. If we have to deal with any metal that is certain, I think it is wrought-iron—I mean iron well hammered, not bar-iron bought in the open market, but iron that is hammered up from scrap until it is clean, so that it does not show any bad seams or anything of that sort.

With regard to the adaptability of wrought-iron and cast-steel for machines of intricate shape, I want to say that it is not the purpose of this paper to attempt to balance the comparative desirability of simple and intricate shapes. There is no question if it is desirable to build machines of intricate shapes, as many think it to be, cast-steel is the metal to use. But for the simple shapes, in which forgings can be had, at as low price per pound as steel castings, the higher permeability, close dimensions and ease of machining make them more desirable.

With regard to the point taken by one gentleman that we might have allowed a greater loss in the field-magnet coils of the

cast-iron machine, that point of course is well taken in a sense. The builder of a cast-iron machine having gone to a good deal of expense in other ways would naturally try to save himself a little by using more watts in the field coils. But the comparison was based on the same coil loss all around, and that is why the figures were carried out on that basis. It is a noticeable fact that some very prominent builders in this country and in Europe, in spite of the very desirable qualities of cast-steel, are using a great deal of cast-iron and wrought-iron in magnet-frames, some of them in very large multipolar machines. I do not myself see any economy in the use of stamped sheet-iron, except where it is necessary to prevent heating of pole-pieces, and from my point of view, that necessity had better be avoided.

It certainly would be cheaper to cast or even to bolt solid pole-pieces of wrought-iron, into their proper places on the inside of multipolar frames, such as I suppose were referred to, than to use stamped sheets for the purpose.

MR. FLEMING:—I would like to add a word in regard to the space necessary to allow for clearance in field spools to go over cast-steel cores. I would say that for moderate sizes, say 12″ in largest dimension; ¼″ is all that is necessary. A small clearance here is not a disadvantage, as it admits of a considerable circulation of air between coil and core, thereby increasing the radiating surface of the coil.

Referring to the design shown in the paper—of course if we confine ourselves to square sections (upright and downright as Mr. Adams expresses it), we cannot improve on the design very well, but there is no necessity of making the cast-iron frame in a single casting as the sketch calls for. In a machine of this class, a better plan would be to make the magnetic circuit in two or more parts, having the field cores of circular section, thereby reducing the mean length per turn of wire embracing them, which would be a considerable saving, and extend the pole pieces sufficiently to embrace the armature, the length of which is determined by the polar span, and the density of magnetization, both of which should be about the same, whether wrought or cast-iron be used.

It is practically out of the question to use forgings for multipolar dynamos unless in conjunction with either cast-iron or steel. When used with cast-iron there is trouble from oversaturation at the junction of the two metals, due to the lower permeability of the cast-iron, unless special precautions be taken to increase the area of contact. This need not be considered if cast-steel is used.

The most economical plan is to use steel throughout, making the magnetic frame in as few parts as possible. As regards the permeability of cast-steel I have experienced no difficulty in getting an induction of 13,000 per square cm. This could be exceeded were it not necessary to allow a little for blowholes and slight imperfections in the castings, though for castings from the

best manufacturers nowadays it is hardly necessary to make any allowance for blemishes.

I do not consider it policy to use higher induction than 13,000 in the average wrought-iron forging. In multipolar machines, if weight and compactness of design have any consideration at all, the advantage is decidedly in favor of cast-steel. The total weight of the machine will be less, the mean length of the magnetic circuit will be less, and by getting any desired section for the field core you will be able to make any compromise that will be deemed necessary in the design of the machine. Kapp has said truly that a dynamo is a compromise all the way through.

MR. ADAMS:—I neglected to call attention to a criticism that was made with reference to the different densities in air-gaps of these two magnet frames. If you will notice what is said in the paper on the subject, you will find that the intention was to expend the same field ampere-turns in the air-gaps of each machine, so that we might expect the same change of brush lead. In other words, it is intended that the ratio of the field ampere-turns to the ampere-turns on the armature, which is, of course, going to determine the action of the machine as to change of brush lead and sparking, other things being equal, would be the same in each machine. I do not know that there is anything necessary about any particular air-gap density. We have air-gaps in two machines here, and each air-gap requires the same number, very nearly, of ampere-turns expended in it to carry across it a certain amount of magnetism. One air-gap we have is comparatively short, $\frac{1}{4}''$ in all. The other is much longer, $1\frac{5}{16}''$. But the area of the short air-gap is so small as to make up in magnetic resistance the advantage it has over the other in the matter of length. The magnetic resistance of the air-gap in each of these two frames presented in the drawing is intended to be nearly the same. I do not know that I have said that there is intrinsically anything better about an air-gap density of 25 or 65,000 one way or the other. We want certain conditions in the air-gaps to control the operation of the machines, and if it had been thought or assumed what different conditions than those suggested here would control the action of the machines when delivering full load, they might have been assumed. They may still be assumed. We may assume, if you please, that we only want the field ampere-turns in air-gaps to be one and one-half times the ampere-turns of armatures, active at pole corners, and design frames to correspond to those conditions, but the same advantages will still hold in the use of wrought-iron.

[Adjourned.]

DIED.

BAUER:—In New York City, January 15th, 1895, Mr. Alexander Henry Bauer, late of Chicago. Mr. Bauer was born in Baltimore, August 9th, 1846. He was elected an associate member of the INSTITUTE, February 7th, 1890, and transferred to full membership April 21st, 1891.

EICKEMEYER:—In Washington, D. C., January 23d, 1895, Mr. Rudolf Eickemeyer of Yonkers, N. Y. Mr. Eickemeyer was elected an associate member of the INSTITUTE, September 20th, 1893, and transferred to full membership April 18th, 1894.

LITTLE:—In Buffalo, N. Y., early in January, Mr. Franklin P. Little, Manager and Secretary, F. P. Little Construction and Supply Co. Mr. Little was elected an associate member of the INSTITUTE, May 17th, 1892.

POSTPONEMENT.

The 94th meeting at New York and Chicago, which is fixed by the calendar for February 20th, has been postponed until February 27th, 1895, in order to avoid conflicting with the meeting of the National Electric Light Association at Cleveland, February 19th, 20th and 21st. This change suggested by the Chairman of the Sub-Committee on Papers and Meetings, has been approved by the President.

RALPH W. POPE, *Secretary.*

New York, February 7th, 1895.

NOTICE.

Written discussions of the paper contained in this issue if acceptable, will be printed in the February number if received before February 15th.

The Secretary will esteem it a favor if his attention is called to any errors in either papers or discussion, in order that they may be corrected before printing the sheets for the annual volume.

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